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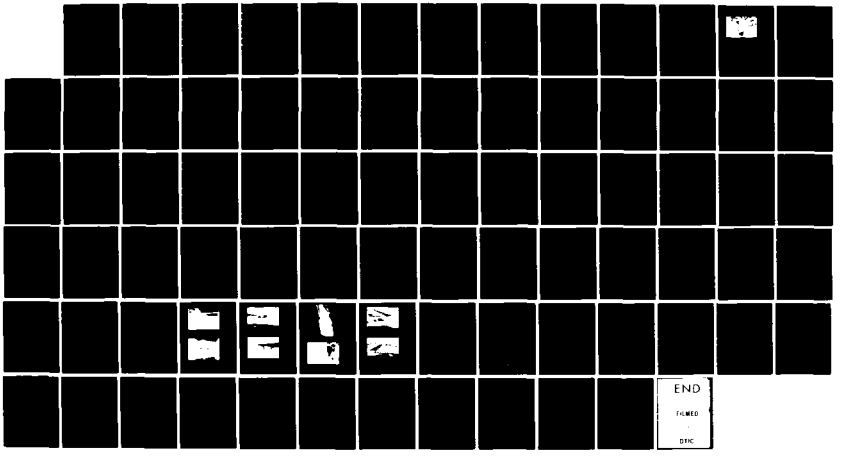
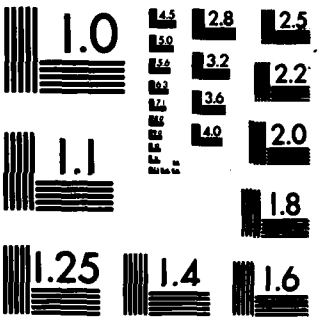
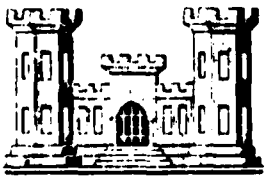




MERRIMACK RIVER BASIN
DUNSTABLE, MASSACHUSETTS

MASSAPOAG POND DAM
MA 00136

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

NOVEMBER 1978

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,
Merrimack River Basin
Dunstable, Mass.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Massapoag Pond Dam is approximately 200 feet long and 12 feet high. The dam is in good to fair condition. Based on the size and hazard classification in accordance with the Corps of Engineers Guidelines, the recommended spillway test flood is the 100 year flood. The hazard classification for this dam is to be changed from high to significant. This recommendation is based on our elevation of the downstream conditions.

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF:

NEDED

JAN 22 1979

Honorable Edward J. King
Governor of the Commonwealth of
Massachusetts
State House
Boston, Massachusetts 02133

Dear Governor King:

I am forwarding to you a copy of the Massapoag Pond Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Department of Environmental Quality Engineering, the cooperating agency for the Commonwealth of Massachusetts. In addition, a copy of the report has also been furnished the owner, Cambridge YMCA, 820 Massachusetts Avenue, Cambridge, Massachusetts 02139, ATTN: Mr. Peter Smargon, Director.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Department of Environmental Quality Engineering for your cooperation in carrying out this program.

Sincerely yours,

JOHN P. CHANDLER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

MASSAPOAG POND DAM
MA 00136

MERRIMACK RIVER BASIN
DUNSTABLE, MASSACHUSETTS

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

Identification No.: MA 00136
Name of Dam: MASSAPOAG POND
Town: DUNSTABLE
County and State: MIDDLESEX COUNTY, MA
Stream: SALMON BROOK
Date of Inspection: 22 & 30 August 1978

BRIEF ASSESSMENT

Massapoag Pond Dam is approximately 200 feet long and 12 feet high. The dam consists of earth embankments on each side of a timber weir. Sidewalls of the weir are constructed of concrete. One 2 ft. x 3 ft. timber gate is present in the timber weir and serves as a reservoir drain. The age of the dam is unknown but records of repair work in 1949 and 1973 have been located.

The dam is in good to fair condition. There are no obvious signs of failure. It is therefore recommended that remedial work should be performed within two years of the owners receipt of this report.

Based on the size and hazard classification in accordance with the Corps of Engineers Guidelines, the recommended spillway test flood is the 100-year flood. Hydraulic analysis indicates that the spillway can only pass 36 percent of the test flood before overtopping the earth embankments. A 100-year test flood outflow would overtop the earth embankments by approximately 1 foot. It is recommended that an investigation be made on the earth embankments for the purpose of increasing the height of the embankments and allow the test flood to be confined to the spillway.

It is recommended that the hazard classification for this dam be changed from high to significant. This recommendation is based on our evaluation of the downstream conditions.

Additional investigations recommended include a detailed investigation to determine the condition of timbers now obscured by flowing water and overall stability of the timber weir as well as the before mentioned investigation to determine a method of increasing the embankment height.

Recommendations for remedial work include the clearing of brush and trees from the embankment, the providing of erosion protection on the upstream face of the dam, the repair of eroded downstream embankment surfaces, the

repair of local deterioration in the concrete sidewalls, and the repair or replacement of exposed timbers in the operating platform and foot bridge as well as repainting exposed timbers.

CAMP DRESSER AND McKEE INC.

Roger H. Wood

Roger H. Wood
Vice-President

This Phase I Inspection Report on Massapoag Pond Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

JOSEPH W. FINEGAN, JR., MEMBER
Water Control Branch
Engineering Division

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

JOSEPH A. MCELROY, CHAIRMAN
Chief, NED Materials Testing Lab.
Foundations & Materials Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I Investigations are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the test flood is based on the estimated "probable maximum flood" for the region (greatest reasonably possible storm runoff), or a fraction thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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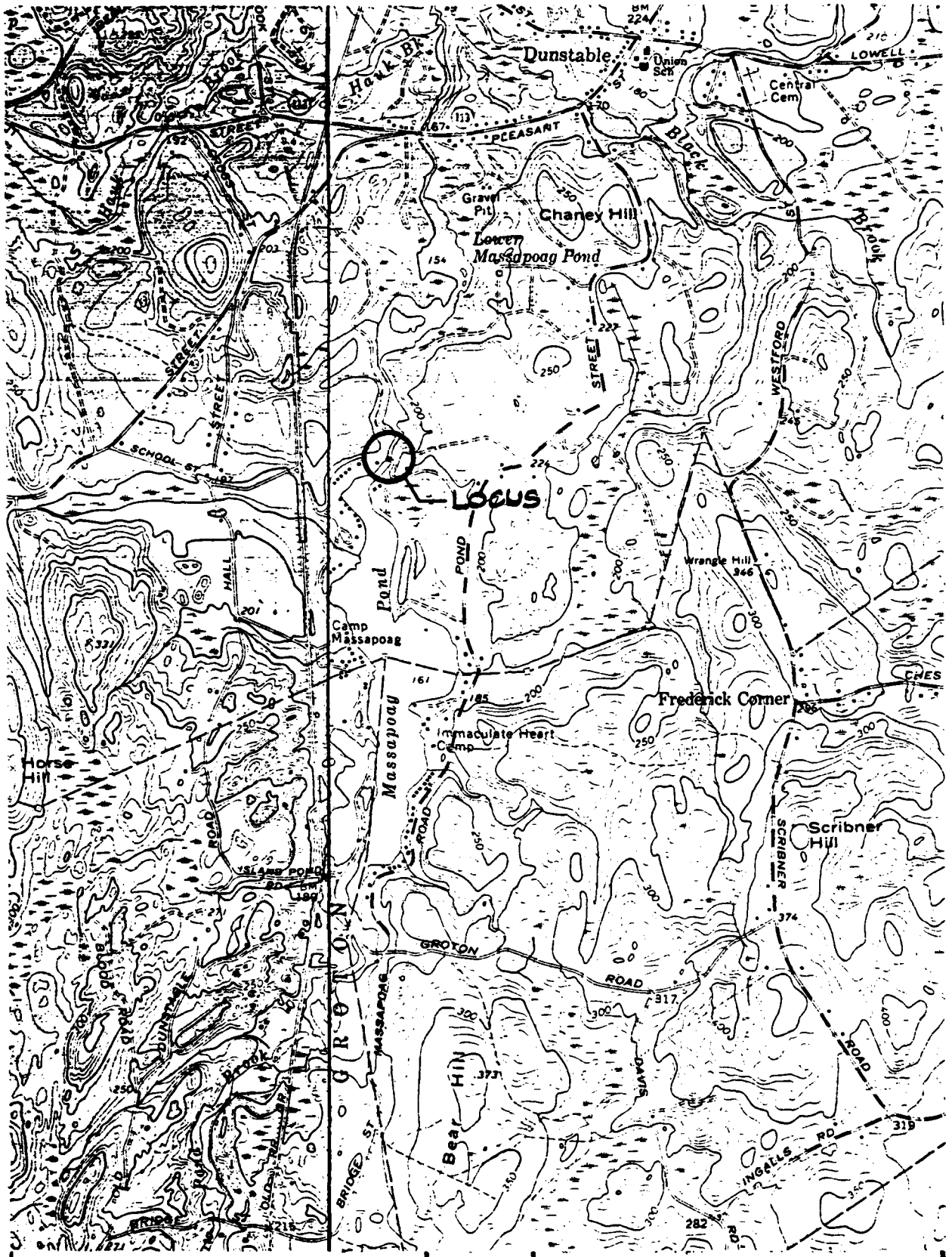
1. OVERVIEW OF DAM FROM LEFT DOWNSTREAM EMBANKMENT. NOTE EROSION CAUSED BY FOOT TRAFFIC AT DAM LEFT ABUTMENT.



DAM: MASSAPOAG POND

IDENTIFICATION NO.: MA.00136

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LOCATION MAP
USGS QUADRANGLE
NASHUA-SOUTH & PEPPERELL, MA
SCALE: 1" = 2000'

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
MASSAPOAG POND DAM
MA 00136

SECTION 1: PROJECT INFORMATION

1.1 General

a. Authority - Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region.

Camp Dresser & McKee Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Massachusetts. Authorization and notice to proceed was issued to Camp Dresser & McKee Inc. under a letter of 12 July 1978, from Colonel John P. Chandler, Corps of Engineers. Contract No. DACW 33-78-C-0354 has been assigned by the Corps of Engineers for this work. Haley and Aldrich, Inc. has been retained by Camp Dresser & McKee Inc. for the soils and geological portions of the work.

b. Purpose - The primary purpose of the investigation is to:

(1) Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

(2) Encourage and assist the States to initiate quickly effective dam safety programs for non-Federal dams.

(3) Update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location - Massapoag Pond Dam is located on Salmon Brook in the Town of Dunstable, Massachusetts, as shown on the report's Location Map. The dam and spillway are located on the northern most portion of Massapoag Pond, approximately 1,500 feet upstream of Lower Massapoag Pond.

b. Description of Dam and Appurtenances - Massapoag Pond Dam consists of an earth embankment with a concrete, steel and timber spillway structure located close to the left abutment. A timber gate and a walkway are incorporated into the spillway structure. The total length of the dam is nearly 200 ft.

The right dam embankment provides approximately 140 ft. of the total dam length. It is typically about 6 ft. high, but slightly exceeds 12 ft. alongside the spillway. Upstream and downstream slopes are somewhat irregular and flatter than 2 horizontal to 1 vertical, except close to the spillway where the downstream slope steepens considerably.

To the left of the spillway structure the dam embankment consists only of a short section of earth fill against the natural slope. It has a maximum height comparable to the right embankment but extends upstream along the spillway training wall to a considerably greater width.

c. Size Classification - The hydraulic height of the structure is approximately 14 feet and the estimated storage capacity at the top of dam is 730 acre-feet. According to guidelines established by the Corps of Engineers, the dam is classified in the small category.

d. Hazard Classification - The dam was originally classified by the Corps of Engineers as having a "high" hazard potential. The dam failure analysis indicates that sufficient flood plain storage exists downstream of the dam site to attentuate the failure outflow before it reaches the City of Nashua, without flooding any structures. If the culverts at Pleasant Street, Main Street, Ridge Road, and Searles Road were washed out, minor flooding could result to a few residences. Since the expected damages would be confined to roads, bridges, utilities, and agricultural lands, it is recommended that the hazard classification be reduced to significant.

e. Ownership - At the time of inspection, the dam was jointly owned by the Cambridge YMCA (58 percent), represented by Peter Smargon, Director Cambridge YMCA, 820 Massachusetts Ave., Cambridge, MA 02139 (Phone: 617/876-3860) and the Pennichuck Water Works (42 percent), represented by John C. Collins, President, 11 High Street, Nashua, N.H. 03060 (Phone: 603/882-5191). At the time of this investigation arrangements were nearing completion for the transfer of the 42 percent portion of ownership from Pennichuck Water Works to the Cambridge YMCA. The Pennichuck Water Works obtained 42 percent ownership from Labombarde Interests in 1963. Labombarde Interests obtained ownership in 1948 from International Paper Box Machine Co.

f. Operator - Mr. Howard Small of the Dunstable Rod and Gun Club is responsible for the operation of the dam. His address is: Hall Road, Dunstable, MA 01827 (Phone: 617/649-7273).

g. Purpose of Dam - The dam was originally constructed to create a storage for release during periods of low flow for power generation by the International Paper Box Machine Co. Today, Massapoag Pond is used for recreational purposes.

h. Design and Construction History - The dam is believed to have been constructed in the early 1900s. No records of the original design and construction are known to exist. The structure was repaired in 1949, the face of the weir replanked and a steel beam inserted for reinforcement. Additional repairs to the left wall and the gate were made in 1973.

i. Normal Operational Procedure - There is no established routine for operation of the dam.

1.3 Pertinent Data

There are no known elevations previously established at the dam site. Consequently, the water surface elevation of 161 shown on the USGS Quadrangle, Nashua South, Mass.-N.H., 1965, was adopted as being the spillway crest elevation. All other elevations given in this report pertaining to the dam site were estimated from the assumed spillway crest elevation.

a. Drainage Area - The drainage area tributary to the dam site is 13.56 square miles. The terrain surrounding the watershed is heavily forested with moderate side slopes. Drainage of the watershed is through a series of lakes, ponds, swamps, and brooks resulting in a rather flat watershed slope. The surface waters and swamps, including Massapoag Pond, account for about 53 percent of the total drainage area.

b. Discharge at Dam Site - There are no records of discharges for Massapoag Pond Dam. The maximum recorded rainfall for the area was approximately 6" between September 17-21, 1938.

(1) Outlet works: 2-ft. wide by 3-ft. high gate at Invert Elev. 151 (Est.)

(2) Maximum known flood at damsite UNKNOWN

(3) Ungated spillway capacity at top of dam.
372 cfs @ 163.65 elev.

(4) Ungated spillway capacity at test flood pool elevation
625 cfs @ 164.74 elev.

(6) Gated spillway capacity at test flood pool elevation N/A

(7) Total spillway capacity at test flood pool elevation 625 cfs @ 164.74 elev.

(8) Total project discharge at test flood pool elevation 1,020 cfs @ 164.74 elev.

c. Elevation (ft. above MSL)

(1) Top of dam Varies from 163.65 to 164.67

(2) Test flood pool-design surcharge 164.74

(3) Design surcharge-original design UNKNOWN

(4) Full flood control pool N/A

(5) Recreation pool 161.0

(6) Spillway crest 161.0

(7) Upstream portal invert diversion tunnel N/A

(8) Streambed at centerline of dam 151.0

(9) Maximum tailwater 161.8

d. Reservoir

(1) Length of test flood pool 1.4 miles (Est.)

(2) Length of recreation pool 1.3 miles (Est.)

(3) Length of flood control pool N/A

e. Storage (acre-feet)

(1) Top of dam 730 @ Elev. 163.65 (Est.)

(2) Test flood pool 880 (Est.)

(3) Flood-control pool N/A

(4) Recreation pool 366 (Est.)

(5) Spillway crest 366 (Est.)

f. Reservoir Surface (acres)

(1) Top of dam 126 @ Elev. 163.65 (Est.)

(2) Test flood pool 133 (Est.)

(3) Flood control pool N/A

(4) Recreation pool 110 (Est.)

(5) Spillway crest 110 (Est.)

g. Dam

(1) Type Earth Embankment

(2) Length Approx. 140 ft., not incl. spillway

(3) Height Approx. 12 ft.

(4) Top width Approx. 12 ft.

(5) Side slopes Irregular, typically approx. 3:1 U/S & D/S

(6) Zoning Unknown, possibly earth fill over stone masonry

(7) Impervious core UNKNOWN

(8) Cutoff UNKNOWN

(9) Grout curtain Probably none

h. Diversion and Regulating Facilities ---------- None

i. Spillway

(1) Type Modified Buttress

(2) Length of weir 25 feet

(3) Crest elevation 161.0

(4) Gates None

(5) U/S channel_____5 ft. rise in 10 ft.

(6) D/S channel_____1,500-ft. to Lower Massapoag Pond

(7) General_____Good hydraulic condition

j. Regulating Outlets - The only regulating outlet at this structure is a 2 ft wide by 3 ft high timber gate with an invert elevation of 151 (estimated). The gate has a timber stem extending to a platform at the top of the dam. The operator for this gate was not present at the structure.

SECTION 2: ENGINEERING DATA

2.1 Design, Construction and Operation Records

No records pertaining to the design, operation, or original construction of the Massapoag Pond Dam were located and none are believed to exist.

Construction records pertaining to repair work performed by C.M. Bacon and Sons, General Contractors, in 1949 and again in 1973 consist of the following:

1. Letter proposal from Mr. Clarence M. Bacon to Mr. Glenn C. Perduyn of the Cambridge YMCA dated March 5, 1949. Proposed work consisted of (A) - Rebuilding cofferdam at old location with a plank spillway 4' wide at center, using sandbag method and backfilling at least 3' with local material; (B) - Repairing hole at bottom of dam by holding water back and filling the hole with granite and clay, well placed and compacted; (C) - Reinforcing top member of spillway by placing a steel beam along the rear of present timber, said beam to be set into concrete walls at both sides at least 8", being well pointed up after setting, and then fit in 4 x 8 blocks to timber and lag in place; (D) - Removing present top walk timbers and placing one 10 x 12 hard pine second hand timber of sound quality to carry gate house timber bolted in place and reinforcing gate house; (E) - Covering the face of the dam (spillway) with new 2" spruce plank, well nailed with 30d spikes and place new plank on gate.

   Some or all of the above proposed work was performed in 1949 but no records were found which detailed the completed repairs.

2. An invoice from C. M. Bacon and Sons to the Cambridge YMCA dated October 23, 1973 summarizes the following work: "Repair work on dam at Lake Massapoag, Dunstable, Mass. required the removal of all wood from the left hand wall on the upper side of the dam (spillway) and replacing the 6" x 6" post set into the concrete. We also removed the gate and installed a new gate with a new post."

   A sketch attached to the above invoice shows a section through the spillway with the following notes:

   "West wall - concrete poured behind original wall"
   "All old timber removed from concrete on lake side"

"New uprights set into concrete"
"Wall double planked with plastic membrane between planks and tied onto dam face"

2.2 Evaluation

Since no engineering records are available, the evaluation of the dam must be based primarily on the results of the visual examination which is detailed in Section 3.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General - The visual examination of the Massapoag Pond Dam was conducted on 22 August 1978. The visual examination of the embankment was conducted on 30 August 1978.

In general, the earth embankments, spillways and outlet facilities were observed to be in good to fair condition. The downstream face of the timber spillway was obscured by flowing water. One entrance in the vicinity of the gate was made beneath the falls to observe the conditions. Further entrances were not made due to the limited visibility and the presence of the falling water.

Visual inspection checklists for both site visits are included in Appendix A and selected photographs are given in Appendix C.

b. Dam - The concrete portions of the dam (the sidewalls of the spillway) were found to have local spalls, some effloresence, minor vertical cracking, and local deterioration as shown in Photo Nos. 2, 4 and 5. Steel bars are present in the exterior surface of the left upstream wall. Deteriorated timbers are present just downstream of the weir in the left concrete wall as shown in Photo No. 6. A void is present on the rear face of the right sidewall at the downstream end as shown in Photo No. 7.

The timber weir was observed to be in good to fair condition. A portion of the downstream face of the timber weir was observed by going beneath the falls. The area observed was that portion immediately adjacent to the timber gate. The timber was found to be waterlogged and some members were found to be easily penetrated to a 3/4 inch depth with a geologist pick. As inidcated above, timber adjacent to the left sidewall is deteriorated. This timber does not currently serve as a support for the weir.

The earth embankment located to the right of the spillway is generally is fair condition. There is no visual evidence of settlement, lateral movement or significant seepage, but there has been local erosion and material loss on the embankment slopes.

The following specific items were noted:

(1) The lower part of the relatively steep downstream slope behind the right spillway wall appears to have been previously repaired by patching with concrete and rock fragments. The dam crest width is also reduced above this location. As shown in Photo No. 7, there is a hole

in the slope that extends 36 in. back into the embankment. The hole is apparently the result of a loss of part of the patching material. There is no evidence that seepage flow has either contributed to or resulted from the hole.

(2) At its lowest point the top of the embankment is nearly 2 ft. lower than the top of the right spillway wall, resulting in approximately a 2 ft. freeboard above spillway crest elevation.

(3) Extensive foot traffic on the slopes and the top of the right dam embankment and the left abutment area has resulted in local erosion, slope flattening and reduction of the dam crest width, as shown in Photo No. 1.

(4) The upstream slope of the dam lacks erosion protection and is partly exposed sand and gravel. Because of the pond geometry, wave action would be expected to be minimal, however.

(5) There is a moderately heavy growth of trees and brush on the downstream slope and there are clumps of brush and young trees on the upstream slope, as shown in Photo Nos. 1, 2 and 3.

c. Appurtenant Structures - The operating platform for the reservoir drain is in fair to poor condition. The end of the support beams for the platform have deteriorated as shown in Photo No. 8. The decking has started to deteriorate on the upstream end. The vertical support posts have deteriorated at the normal water surface line. One of the posts appears to have a temporary support scarfed onto it. The downstream face of the gate appears to be waterlogged timbers. The operator for the gate is not present at the spillway. Inspection records indicate that this gate was repaired in 1973. It is believed to be operational and it is estimated that it is operated by a pry bar.

The footbridge over the weir is in fair condition. A few of the deck planks are missing and the ends of the timber stringers have started to deteriorate as shown in Photo Nos. 8 and 9. The foot bridge and the operator platform require replacement of individual members and painting.

d. Reservoir Area - The area around Massapoag Pond is generally wooded and extensively developed. There are approximately 3 cottages below test flood pool elevation 164.74. Present shoreline development at or below elevation 180 consists of approximately 77 cottages, 2 camps, and 350 feet of streets and roads. Although the dam site is located in the town of Dunstable, portions of the pond are located in Dunstable, Tyngsborough, and Groton.

The side slopes to the pond are highly variable and generally wooded. There is no significant potential for landsides into the pond which could create waves that might overtop the dam. No conditions were noted which could result in a sudden increase in sediment load into the pond.

e. Downstream Channel - Immediately downstream of the dam is Lower Massapoag Pond followed by Pleasant Street - Rt. 113. The road elevation at the Pleasant Street culvert is estimated to be 166.0. The culvert is an 84" diameter corrugated metal pipe approximately 60 feet long. In the event of a dam failure, Pleasant Street would act as a secondary dam without being overtopped. The flood plain surrounding Lower Massapoag Pond, which would be inundated should the Massapoag Pond Dam fail, is presently undeveloped.

3.2 Evaluation

Based on visual observations during the site examination, the general condition of the project is good to fair. The concrete portion of the dam is in good condition with local spalls, minor cracks and limited deterioration present. The exposed timber portion of the dam, including the operator platform and foot bridge, are in fair condition. These items are showing deterioration, especially at the juncture of timber and concrete and timber and water. The portion of the dam containing timber continuously exposed to water is in good to fair condition. The timbers in this area are generally waterlogged with members showing loss of strength in the outer 3/4 of an inch.

While the embankment at the Massapoag Pond Dam is performing satisfactorily at the present time, the limited freeboard and partially unprotected slopes appear to provide significant potential for dam failure under conditions of higher than normal water levels.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures - In general, there is no established routine for the operation of the dam.

4.2 Maintenance of Dam - The dam receives little maintenance except for occasional repairs.

4.3 Maintenance of Operating Facilities - The operating facility, including the timber gate, has received minimal maintenance. There is no formal maintenance procedure for this operating facility.

4.4 Description of any Warning System in Effect - There is no established warning system or emergency preparedness plan in effect for this structure.

4.5 Evaluation - For a structure of this type and classification, a periodic observation and maintenance program should be established to examine the dam, control tree and brush growth, maintain slopes, and maintain the timber weir and operating gate. This structure should be observed during unusually high rainfalls.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design Data - No hydraulic/hydrologic design data is available concerning this dam. Hydrologic analysis performed by Metcalf & Eddy, Engineers in 1960 estimated the "maximum expected flood flow" to be 2,900 cfs based on the Kinnison-Colby Formula (Rare Floods). They further estimated that "If the spillway abutments and embankment crest were raised 2.5 ft., the head on the spillway of 6.5 ft together with the storage in the pond would take the flow of 2,900 cfs."

Based upon the Corps of Engineers Guidelines, the recommended test flood for the size (small) and hazard potential (significant) is within the range of 100-year to 1/2 PMF (Probable Maximum Flood). Since the hazard potential is considered to be at the bottom end of the significant range (no expected structural damage), the 100-year flood shall be adopted as the test flood.

b. Experience Data - The test flood (100-year) was estimated by two regional frequency analysis methods. The first method, developed by C. G. Johnson and G. P. Tasker of the USGS Water Resources Division resulted in a peak inflow of 913 cfs. The second method developed by S. W. Wandle entitled USGS Water Resources Investigation 77-39 resulted in a peak inflow of 1,060 cfs. The results of these two independent methods compare reasonably well and the more conservative value of 1,060 cfs has been adopted as the test flood inflow.

Surcharge-storage routing thru Massapoag Pond was performed to estimate possible flow reductions. The attenuating effect of the pond was found to be minimal and the test flood outflow was estimated to be 1,020 cfs.

c. Visual Observations - The hydraulic condition of the spillway, including the approach and discharge channels, were observed to be in good condition. It was noted during the inspection that the right spillway abutment is approximately 7 inches higher than the left abutment.

A 3 foot wide wooden foot bridge spans the spillway and is located 3'-7" above the spillway crest. Discharges at or above this stage would be affected by this structure. However, the dam would be overtopped before this stage is reached as the lowest point on the earth embankment to the right of the spillway was estimated to be approximately 1 foot lower than the bottom of the walkway.

d. Overtopping Potential - The maximum capacity of the spillway with the pool elevation at the top of dam (Elev. 163.65) is 372 cfs

which is about 36 percent of the test flood. The amount of flow passing over the spillway at test flood pool elevation 164.74 is 625 cfs which is about 61 percent of the test flood. At the test flood discharge elevation of 164.74, the low point of the right embankment will be overtopped by approximately 1 foot.

e. Evaluation - Dam failure analysis was performed to determine the magnitude of downstream hazards. A peak failure outflow of about 2,800 cfs was estimated based on a 40 percent breach width of the right embankment. The analysis indicates that the Pleasant Street road and culvert, which is located about 1 mile downstream of the dam site, would act as a secondary dam with top of road at about elevation 166.0. The flood plain between the dam site and Pleasant Street consists of swamp and marshlands surrounding Lower Massapoag Pond. There is no development which would be affected by this flooding. The outflow from this reach would be controlled by the 84-in. diameter corrugated metal culvert. The sudden release of flow from Massapoag Pond by a breach would cause a rapid increase in the level of lower Massapoag Pond until its level coincided with the declining level of Massapoag Pond, at which time the two bodies of water would act as a single unit. The maximum water level in the combined ponds (Elev. 160.8) would represent a drop in water level of Massapoag Pond of only 2.85 ft. and the 84in. culvert would have a maximum outflow rate of about 370 cfs which would decline steadily after the above described equilibrium condition had been achieved. Although the additional storage in the swampy area between Pleasant and Main Streets would very likely attenuate this flow even further, the Main Street culvert could convey the 370 cfs flow rate with a total head loss of 0.82 ft., thereby resulting in a freeboard of more than 1.5 ft. at the Main Street culvert. Some flooding of the agricultural and low lands in the half mile reach between Pleasant and Main Streets would occur, but no structures would be affected. Salmon Brook, which flows from Lower Massapoag Pond to the Merrimac River, has more than adequate capacity to attenuate the 370 cfs as there is ample flood plain storage with no structural development for the next 3 miles downstream of Main Street.

In conclusion, the Massapoag Dam spillway is inadequate to pass the test flood and in the event of a dam failure, damages to only roads, culverts and agricultural lands would occur.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations - There was no visible evidence of dam instability during the site examinations on the 22nd and 30th of August 1978. There was no evidence of movement of structural items. There was no evidence of embankment erosion or piping at a location of very slight seepage below the left spillway wall, and no evidence of seepage flow at the hole behind the right spillway wall. Therefore, seepage is not considered to pose a hazard to the stability of the downstream slopes.

b. Design and Construction Data - There were no design and construction data available. Letters pertaining to repairs made in 1949 and 1973 were located. The 1949 letter indicates the strengthening of the spillway by adding a steel beam. A review of the letters indicate that the strengthening of the spillway was probably required due to deterioration of the structure rather than being required by inherent structural instability. Except for the May 1960 inspection report references to indications of earth embankment construction over original dry stone masonry, there are neither design drawings nor construction data which would show the embankment cross section and the physical properties of the materials in the embankments. The lack of significant seepage does indicate that the dam has a core material less pervious than the granular soils that are exposed at the surface.

   The Massapoag Pond Dam is relatively low, and, in the absence of significant seepage, the typical 12 ft. top width and flatter than 2 horizontal to 1 vertical upstream and downstream slopes would be expected to provide adequate stability for present pond levels under static loading conditions.

c. Operating Records - There are no known operating records available for the dam.

d. Post-Construction Changes - Post construction changes have been made to the spillway. Changes to the spillway walls and to the support of the timber weir are mentioned in C.M. Bacon and Sons letters of March 5, 1949 and October 23, 1973 included in Appendix B. These letters indicate that the walls were originally of timber and that they have been replaced with concrete walls. They also indicate that the timber weir has been reinforced by the addition of a steel beam beneath the timbers. Support posts beneath the timber weir have either been replaced or new supports have been added. There are no known post-construction changes to

the dam embankment, although as noted in Section 6.1b., there may have been an original dry stone masonry dam. Previous inspection reports have recommended raising the dam embankment, but this has apparently not been done.

e. Seismic Stability - Massapoag Pond Dam is located in Seismic Zone No. 2 and in accordance with recommended Phase I guidelines does not warrant seismic analysis.

SECTION 7: ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition - The visual examination of the Massapoag Pond Dam embankment did not reveal any evidence of potential failure, but it did disclose a potential for overtopping by high water. The spillway, due to the low elevation of the adjacent embankments, was determined inadequate to pass the test flood. This potential warrants near term remedial treatment. Because of this, and the condition of the spillway, the project is considered to be in only fair condition.

Maintenance should be performed and an additional investigation undertaken as outlined hereinafter.

b. Adequacy of Information - Since there were no available drawings, all information for the Phase I Investigation has had to be obtained from visual examination and limited measurements at the site. This information has been sufficient for the purpose of this investigation, but it does not permit the further evaluation of stability of embankments and spillway and embankment seepage that would be necessary if the embankment is to be raised.

c. Urgency - The recommended additional investigation and remedial measures outlined in Sections 7.2 and 7.3, respectively, should be undertaken by the Owner within the next two years after receipt of this report.

d. Need for Additional Investigations - Additional investigation should be performed by the Owner as outlined in the following section.

7.2 Recommendations

It is recommended that the Owner engage a registered professional engineer to undertake the following investigations:

1. An investigation to arrive at modifications to the embankment cross section to raise the crest elevation. The investigation should include topographic survey to determine the configuration of the present embankment and test borings to determine the character of the embankment and the foundation and abutment soils.

2. An investigation during a period of no flow over the spillway weir to determine the detailed dimensions of the weir and the detailed condition of the individual timbers.

7.3 Remedial Measures

a. Operation and Maintenance Procedures - It is recommended that the following remedial work be undertaken by the Owner, in addition to the investigation outlined in section 7.2, to correct deficiencies noted during the visual examination:

1. Repair and restore the downstream embankment slope and the dam crest width behind the right spillway wall by improving erosion protection at the toe, removing loosened or undermined material and vegetation on the slope, and reconstructing the slope to adequate dimensions.

2. Clear brush and trees from the embankment, including stump removal and backfilling, establish a vegetative cover, and cut grass and weeds on the embankment at least once a year.

3. Provide erosion protection where it is lacking or deficient on the upstream face of the dam, and repair locations where the dam cross section has been reduced due to foot traffic or water action.

4. Replace the deteriorated members in the operating platform and footbridge.

5. Paint all exposed timber members to minimize future deterioration.

6. Remove all minor vegetation from concrete surfaces and remove all deteriorated concrete. Local spalled and eroded areas should be patched.

7. Remove the deteriorated timbers from the left sidewall just below the timber weir and replace the removed timbers with concrete.

Items 2. and 3. of the recommended remedial work will probably be combined with dam modifications to raise the crest elevation that would result from the additional investigation recommended in Section 7.2.

Due to the hazard potential and condition of this dam, surveillance of the dam should be provided by the Owner during and following periods of unusually high precipitation. The Owner should also develop a formal emergency procedures plan and warning system in cooperation with local officials in downstream communities. Finally, it is recommended that the owner establish a formal program of annual technical inspections.

APPENDIX A

INSPECTION TEAM ORGANIZATION AND CHECK LIST

	Page No.
VISUAL INSPECTION PARTY ORGANIZATION	A-1
VISUAL INSPECTION CHECK LIST	
Dam Embankment	A-2
Spillway	A-3
Outlet Works	A-5
Hydrologic-Hydraulic Considerations	A-6
Sketch of Dam	A-7

VISUAL INSPECTION PARTY ORGANIZATION

NATIONAL DAM INSPECTION PROGRAM

DAM: Massapoag Pond

DATE: August 22, 1978

TIME: 5:15 p.m.

WEATHER: Clear - calm - 75° F

WATER SURFACE ELEVATION UPSTREAM: 1-1/4" above spillway crest.

STREAM FLOW: $Q=(3.2)(24.67')(0.10')^{\frac{3}{2}} = 2.50$ cfs

INSPECTION PARTY:

1. Roger H. Wood
2. Joseph E. Downing } CDM
3. Charles E. Fuller
4. Peter LeCount - Haley & Aldrich (8-30-78)
5. _____
6. _____

PRESENT DURING INSPECTION:

1. _____
2. _____
3. _____
4. _____

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Massapoag Pond DATE: 8/30/78

EMBANKMENT: Dam

CHECK LIST	CONDITION
1. Upstream Slope	
a. Vegetation	1. a. Brush & young trees except where bare sand & gravel.
b. Sloughing or Erosion	b. Bare areas, apparently erosion from foot traffic
c. Rock Slope Protection - Riprap Failures	c. None evident
d. Animal Burrows	d. None observed
2. Crest	
a. Vegetation	2. a. Sparse grass in sand & gravel
b. Sloughing or Erosion	b. Slight erosion from foot traffic & at top of paths
c. Surface cracks	c. None evident
d. Movement or Settlement	d. No indication that irregularity is due to settlement.
3. Downstream Slope	
a. Vegetation	3. a. Trees (to 18" dia.), some brush except at paths.
b. Sloughing or Erosion	b. Erosion due to traffic on paths; patching w/concrete & rock behind end of rt. training wall; some of the rock has been lost (36" deep hole exposed.)
c. Surface cracks	c. None evident
d. Animal Burrows	d. None observed
e. Movement or Cracking near toe	e. None evident
f. Unusual Embankment or Downstream Seepage	f. None significant observed
g. Piping or Boils	g. None evident
h. Foundation Drainage Features	h. None evident
i. Toe Drains	i. None evident
4. General	
a. Lateral Movement	4. a., b., c. Embankment & slopes generally irregular; embankment ≈2' lower than top of training walls rt. of spillway.
b. Vertical Alignment	
c. Horizontal Alignment	
d. Condition at Abutments and at Structures	d. Erosion & loss of soil at ends of training walls
e. Indications of Movement of Structural Items	e. None observed
f. Trespassing	f. Extensive foot traffic
g. Instrumentation Systems	g. None evident

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Massapoag Pond DATE: August 22, 1978

SPILLWAY: _____

CHECK LIST	CONDITION
1. Approach Channel	
a. General Condition	1.a. Walls in fair condition. Rt. wall has spalls and efflorescence. Lt. wall has spalls, eroded vert surface, exposed grab bars or reinforcing bars and efflorescence.
b. Obstructions	b. None observed
c. Log Boom etc.	c. None
2. Weir	
a. Flashboards	
b. Weir Elev.	
c. Vegetation	2.a. None observed
d. Seepage	b. 161±
e. Rust or Stains	c. None noted
f. Cracks	d. Visibility obscured
g. Condition of Joints	e. N.A. timber
h. Spalls, Voids or Erosion	f. N.A. timber
i. Visible Reinforcement	g. N.A. timber
j. General Struct. Condition	h. N.A. timber
	i. N.A. timber
	j. Various timbers in weir and weir support are waterlogged. Some can be easily penetrated up to 3/4" with a geologist pick. Timber weir considered in fair condition.
3. Discharge Channel	
a. Apron	3.a. Apron observed only in outlet area.
b. Stilling Basin	b. None
c. Channel Floor	c. Natural stream bed, scattered rocks on surface.
d. Vegetation	d. Trees and brush at edges of stream bed and on banks.
e. Seepage	e. None observed
f. Obstructions	f. Minor obstructions including one tree across stream.
g. General Struct. Condition	g. Good struct. condition but see 4 walls.
4. Walls	
a. Wall Location _____	4.a. (1) grass top of lt. abut.
(1) Vegetation	(2) Local efflorescence both walls.
(2) Seepage or Efflorescence	(3) None noted
(3) Rust or Stains	(4) Cracks both walls.
(4) Cracks	(5) Good condition
(5) Condition of Joints	(6) Top of rt. wall spalled. Downstream end of lt. wall shows exposed rotted timbers.
(6) Spalls, Voids or Erosion	(7) None observed
(7) Visible Reinforcement	(8) Fair to good condition except rotted timbers in lt. wall. This area is in poor condition.
(8) General Struct. Condition	

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Massapoag Pond DATE: August 22, 1973

SPILLWAY:

CHECK LIST	CONDITION
5. Bridge a. General Struct. Condition	5.a. The bridge over the spillway is in fair struct. condition. The ends of the stringers are rotted. A few of the deck planks are missing. The entire struct. including railing needs painting.

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Massapoag Pond DATE: August 22, 1978

OUTLET WORKS:

CHECK LIST	CONDITION
1. Inlet a. Obstructions b. Channel c. Structure d. Screens e. Stop Logs f. Gates	1. See spillway checklist
2. Control Facility a. Structure b. Screens c. Stop Logs d. Gates e. Conduit f. Seepage or Leaks	2.a. Timber struct. Support of platform in poor condition. Ends of horiz. support rotted. Vertical supports indicate deterioration at waterline. b. None c. None d. 25" x 38" timber gate; gate appears waterlogged. e. None f. Small leaks at gate.
3. Outlet a. Structure b. Erosion or Cavitation c. Obstructions d. Seepage or Leaks	3.a. The gate outlets between the Rt. abut. wall and a waterlogged timber bulkhead. The floor is a concrete mat with indications of being in good condition.
4. Mechanical and Electrical a. Crane Hoist b. Hydraulic System c. Service Power d. Emergency Power e. Lighting f. Lightning Protection	4. No mechanical or electrical items.

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Massapoag Pond DATE: August 22, 1978

HYDROLOGIC-HYDRAULIC CONSIDERATIONS:

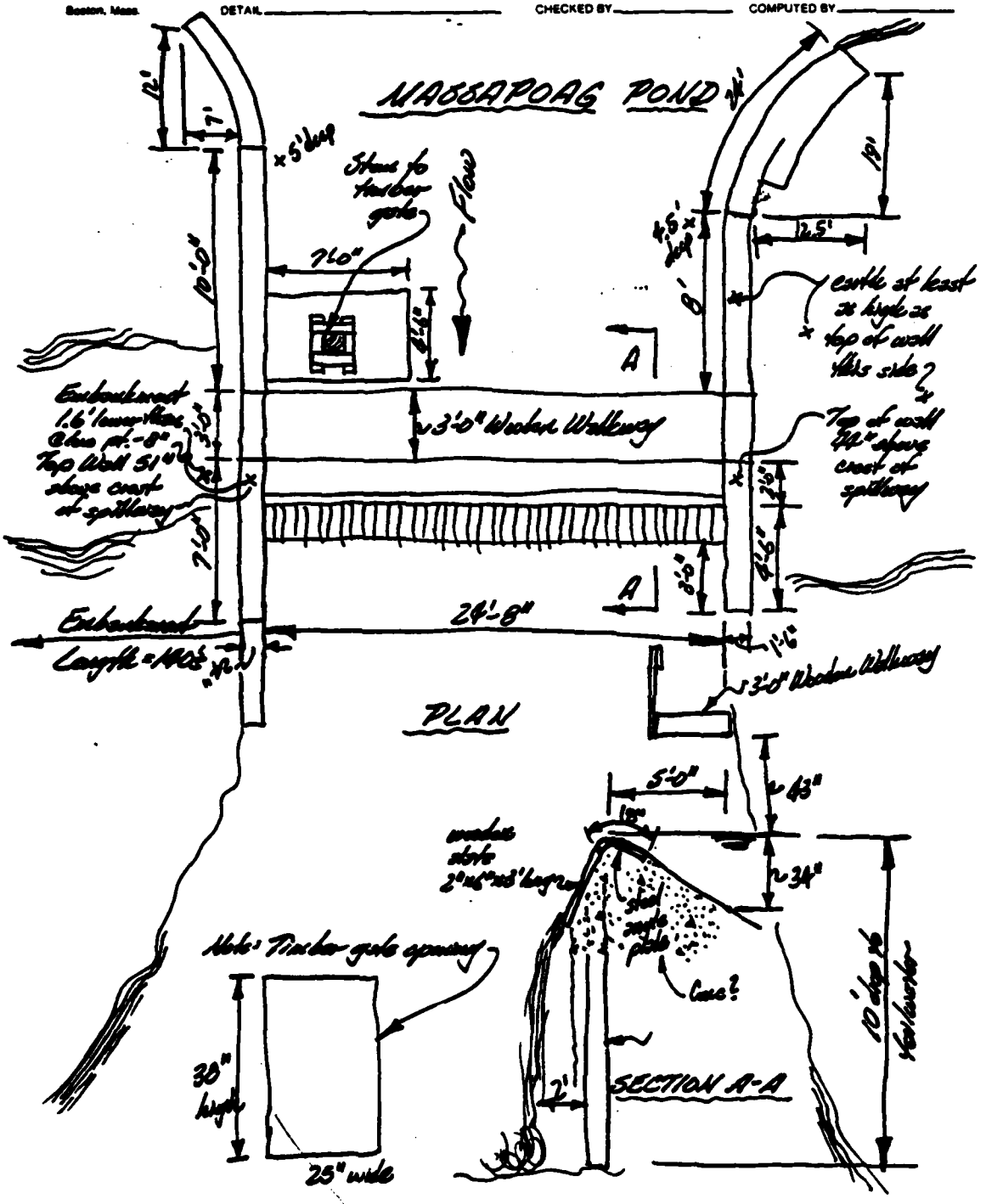
CHECK LIST	CONDITION
1. Upstream Watershed	
a. Type of Terrain	1. a. Gentle to rolling terrain-moderately hilly.
b. Hydrologic Controls	b. Substantial upstream ponds & swampy area (Knopps Pond, Lost Lake, Whitney and Baddacock Ponds).
2. Reservoir	
a. Type of Terrain	2. a. Moderate to steep hills or sandy hills.
b. Development	b. More than 50 summer cottages and year-round homes along shoreline; also Camp Massapoag (YMCA).
3. Spillway	
a. Adjacent Low Points	3. a. On right embankment small area 1.5' low, left okay.
b. Spillway Approach (Slope)	b. 4.5 ft. vert. on 13 ft. hor.
c. Spillway Discharge (Slope)	c. 4 ft. vert. on 1.5 ft. hor. (2" x 6" wooden slats)
d. Spillway Type	d. Modified buttress cantilevered on wooden posts & beams.
4. Downstream Watershed	
a. Reach No. 1	4. a. Lower Massapoag Pond
(1) Control (Bridge, dam, culvert, etc.)	(1) Outlet channel and Route 113 culvert.
(2) Channel Characteristics	(2) Pond is about 1 mile in length with max. width of 800 ft.
(3) Development	(3) Very sparse
(4) Visible Utilities	(4) None
(5) Special Problems (Hospital, etc.)	(5) None
b. Reach No. 2	b. Salmon Falls Brook
(1)	(1) Channel, adjacent swampy area & Main St. culvert.
(2)	(2) Channel has very mild slope with adjacent swampy areas.
(3)	(3) No development within or adjacent to flood plain.
(4)	(4) None
(5)	(5) None

CAMP DRESSER & McKEE
Environmental Engineers
Boston, Mass.

CLIENT
PROJECT
DETAIL

JOB NO.
DATE CHECKED
CHECKED BY

PAGE
DATE
COMPUTED BY



APPENDIX B

LIST OF AVAILABLE DOCUMENTS AND FIELD INSPECTION REPORTS

Page No.

LIST OF AVAILABLE REFERENCES

G. H. Bacon, Contractor, correspondence to Cambridge YMCA B-1

Report Upon Mannapaug Pond Dam B-4

FIELD INSPECTION REPORTS

	DATE	BY	
1.	May 24, 1960	Middlesex County Engineer	B-8
2.	October 17, 1973	Mass. Dept. of Public Works	B-10
3.	November 17, 1973	Mass. Dept. of Public Works	B-14

[illegible]ES — INVESTMENT PROPERTIES — GARAGES — STORE FRONTS — GENERAL REPAIRS — CONCRETE AND MASONRY WORK
ELECTRIC FLOOR SURFACING — PAINTING, ETC. — PLANS AND SPECIFICATIONS DEVELOPED TO SUIT CUSTOMER'S IDEAS

C. M. BACON & SONS

CLARENCE M. BACON

Architect and Builder

A COMPLETE BUILDING SERVICE — SERVING THRUOUT NEW ENGLAND

REAL ESTATE
[illegible] EXCHANGE,
[illegible] INVESTMENTS,
[illegible] A SPECIALTY

RESIDENCE AND OFFICE
NORTH CHELMSFORD, MASS.
TELEPHONE LOWELL [illegible] 0-32

CONSTRUCTION
STORE FRONTS AND FIXTURES
RESIDENTIAL AND COMMERCIAL
GENERAL CONTRACTOR

March 5, 1968

[illegible] Young Men's Christian Association
[illegible] Avenue
[illegible] Massachusetts

[illegible] RE: Dam [illegible]

[illegible] of last week, I hereby submit the follow-[illegible]:-

[illegible] old location [illegible] spillway [illegible] and rock filling [illegible] would cost the sum of [illegible].

[illegible] If this is not done as a whole, [illegible] total of [illegible] (Item B, [illegible] (Item E), as we [illegible] these items.

[illegible] well placed and [illegible] cost [illegible].

[illegible] spillway [illegible] steel beam [illegible] set into concrete walls [illegible] then [illegible] log in place, would cost the sum of [illegible]

[illegible]

[illegible] new [illegible] cost $200.00.

[illegible] of [illegible].

Respectfully submitted

APPENDIX B-1

C. M. BACON & SONS

BY: Clarence M. Bacon

OUR MOTTO + GOOD WORKMANSHIP + GOOD MATERIAL + FAIR PRICES = GOOD BUSINESS

E. M. Bacon and Sons

GENERAL CONTRACTORS

Forest Hill Road • Dunstable, Mass.

HARRY M. BACON

TEL. TYNGSBORO Niagara 9-6517

[illegible] "BUD" BACON
[illegible] Dunstable Road
[illegible] Chelmsford, Mass.
[illegible] Maine 1-6502

[illegible] W. BACON
[illegible] Pleasant Street
[illegible] Dunstable, Mass.
[illegible] Niagara 9-6163

CLARENCE M. BACON
[illegible]

MRS. "DAT" BUCKINGHAM
[illegible] Westford Road
Chelmsford, Mass
[illegible] 6-2801
[illegible] Office

October 23, 1973

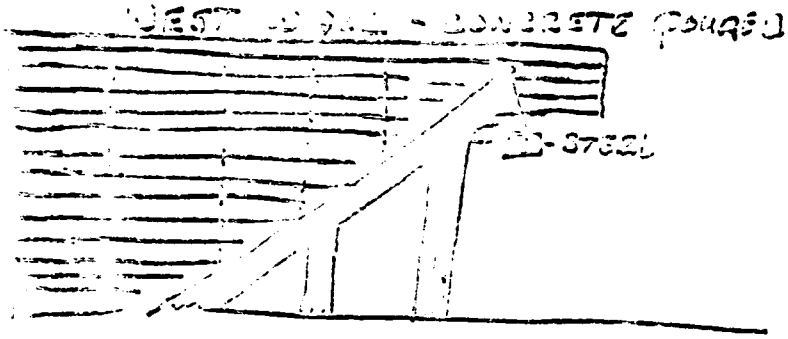
Cambridge Y.M.C.A.
Cambridge, Mass.

Repair work on dam at Lake Massapog, Dunstable, Mass. required the removal of all wood from the left hand wall on the upper side of the dam and replacing the 6" x 6" post set into the concrete. We also removed the gate and installed a new gate with a new post.

Material & Equipment		$200.00
Labor - 88 hours @ $7.50		660.00
	Total	$860.00

APPENDIX B-2

WEST SIDE - CONCRETE POURED BEHIND ORIGINAL ROCK WALL



NEW OAK TIMBER REINFORCED RCDA CONCRETE ON KARST SIDE
WITH UPRIGHTS SET INTO CONCRETE.
WALL DOUBLE PLANKED WITH PLASTIC MEMBRANE
BETWEEN PLANKS & TIED INTO DAM FACE.

J-MCC Dam Survey
GET-js
6/21/60

REPORT
UPON
MASSAPOAG POND DAM
DUNSTABLE, MASSACHUSETTS

General

The Massapoag Pond Dam across Salmon Brook is located in Dunstable Township at Pond Street about 1700 yards south of State Route 113. The dam is of earth construction with a concrete spillway. The structure is about 200 ft. long and 12 ft. high. The 120 acre pond is used for recreation.

The spillway is about 25 ft. long and 8-1/2 ft. high. The depth of waterway opening is 4.1 ft. The structure is a trapezoidal type with a crest width of about 1 ft., the upstream face sloping about 1-1/2 to 1 and the downstream face on about a 1 to 3 slope. This downstream slope is for a depth below the crest of 3 ft. The surface then slopes upstream.

The embankment to the right of the spillway is about 150 ft. long. Its crest varies in elevation so that the lowest point is about 1.6 ft. lower than the top of the abutment walls. The indications are that this structure was a stone masonry dam and that the earth embankment section was recently constructed over it. The downstream slope is about 2-1/4 to 1 and the upstream slope is about 2-1/2 to 1.

There is a timber footbridge across the top of the spillway abutments. A wooden gatehouse is on the right end of the spillway. There is a gate of unknown size in the spillway under the gatehouse. Water flow conditions did not permit an examination of this gate at the time of the last inspection.

Conclusions and Recommendations

1. The existing potential spillway capacity of the dam together with the available storage in the pond is not sufficient to accommodate a Rare Flood as determined by the Kinnison-Colby Formula.
2. The crest of the embankment should be brought up to the level of the spillway abutments as an immediate repair.
3. The spillway capacity should be increased by increasing the height of the embankment and abutment walls by at least 2.5 ft. or by any other approved method.

Spillway Capacity and Flood Flows

The present capacity of the 25 ft. long spillway is estimated to be 345 cfs. (cubic feet per second). Only 2.5 ft. of the 4.1 ft. depth of spillway was considered effective due to the low crest of the right embankment. If the embankment were brought up to the level of the top of the spillway abutment walls, the capacity of the spillway would be 725 cfs. without provision for freeboard. The tributary drainage area above the dam is 11.83 square miles.

Runoff from about 47 percent of the drainage area was considered in computing the flood flow. The remaining 53 percent of the drainage area consists of considerable pond and marsh area which would provide much storage for and retard the runoff. The maximum expected flood flow is estimated from the Kinnison-Colby Formula (Rare Floods) as 2900 cfs. This rate of flow would be about four times what the spillway would be capable of carrying after the embankment had been brought up to the top of the spillway abutment walls.

If the spillway abutments and embankment crest were raised 2.5 ft., the head on the spillway of 6.5 ft. together with the storage in the pond would take the flow of 2900 cfs.

Stability and Repairs

The stability of the structure appears adequate. The earth embankment should in any event be brought up to the level of the top of the spillway abutment walls. When increasing the height of the dam 2.5 ft., the material should be well compacted, the top width of embankment made not less than 10 ft. and the embankment slopes not steeper than 2-1/2 to 1 on the upstream side and not steeper than 2 to 1 on the downstream side. The abutment walls should be raised accordingly and extensions made to the wasteway channel walls.

By: Gordon E. Thomas
Gordon E. Thomas
Project Engineer

Site 1211

Location: Approximately 150 feet downstream at an existing dam between Massapoag Pond and Lower Massapoag Pond in Dunstable, Mass.

Facilities Affected:

Below design high water elev. - 200
- 90 Cottages
- 1 house
- 1 Massapoag Camp
- 1 Day Camp
- 1100 feet of Hall St.
- 200 feet of Curve St.
- 150 feet of Route 140

Below design high water elev. - 195
- 87 cottages
- 1 house
- 1 Massapoag Camp
- 1 Day Camp
- 400 feet of Hall St.

Below design high water elev. - 190
- 87 Cottages
- 1 house
- 1 Massapoag Camp
- 1 Day Camp

For elevations higher than 185, Massapoag Rd. and Pond St. are assumed abandoned. Bridge St., Wharf Rd. and Groton Road (all gravel roads) are assumed abandoned for all elevations. For elevations less than 185 it probably would be economically feasible to raise short sections of Massapoag Rd. and Pond St.

Below design high water elev. - 185
- 82 cottages
- 1 Massapoag Camp
- 1 Day Camp
- 200 feet of Massapoag Rd.
- 1300 feet of Pond St.

Below design high water elev. - 180
- 77 Cottages
- 1 Massapoag Camp
- 1 Day Camp
- 200 feet of Massapoag Rd.
- 150 feet of Pond St.

Below design high water elev. - 175
- 72 Cottages
- 1 Massapoag Camp
- 1 Day Camp

Below design high water elev. - 170
- 38 Cottages
- 1 Massapoag Camp

Below design high water elev. - 165
- 3 cottages

Geologic Conditions: Both abutments are outwash sand and gravel. The found is outwash sand and gravel over glacial till or bedrock which is probably shallow. There are no apparent leakage problems at the present water level being maintained in Massapoag Pond. Borrow material for dam construction is available on site

Dunstable DAM NO. C-4

ION Outlet Massapoag Pond off Pond Street STREAM Salmon Brook

MIDDLESEX COUNTY ENGINEERING DEPARTMENT
CAMBRIDGE, MASSACHUSETTS

D A M I N S P E C T I O N R E P O R T

Cambridge YMCA Cambridge, Mass.
by International Paper Box Machine Co. Place Nashua, N. H. Use Recreation

cted by Joseph S. Krzywicki Date May 24, 1960

of Dam Earth fill (see note) Condition Good

WAY Length 24.9 ft. Ht. to Top Emb. Section 4.1 ft.

boards in Place none Ht. of Recent Repairs

tion Good

rs Needed None visible

MENT Length Height 12 ft. Type

Repairs Fill added (see note)

ion Fair

s Needed Remove trees, build up low areas on top embankment

Number One Size Unknown Types Unknown

Repairs None visible

ion Not visible

Needed Not able to be observed

Detailed Description and Location on Back of Sheet

ous None visible

May 24, 1960 Mass. P.E. 10430
Signature Inspecting Engineer

ion - See Back of Sheet Engineer, Metcalf & Eddy
Title

Remarks and Characteristics on Back of Sheet

APPENDIX B-8

None visible.

ENDED ACTION: Re inspection of spillway during low water period.
See attached report.

L REMARKS: There are indications that the original dam was constructed
ry stone masonry and that it has been raised by the addition of earth fill.

DESCRIPTION OF DAM
DISTRICT #4

mitted by FRANCIS H PARÉ & ADAM Z PIZAN
e 11-14-73

Dam No. 4-9-81-2
~~City~~/Town DUNSTABLE
Name of Dam MASSAPOAG POND DAM

DUNSTABLE ROD & GUN CLUB, DUNSTABLE, MASS. 01827

Location: Topo Sheet No. 25A
Provide 8½" x 11" in clear copy of topo map with location of Dam clearly indicated.

Year built: UNKOWN Year/s of subsequent repairs 10-17-73

Purpose of Dam: Water Supply ____. Recreational ✓
Irrigation ____. Other ____

Drainage Area: 11.83 SQ. Mi. 7571.20 ACRES.

Normal Ponding Area: 120 acres; Ave Depth 5'
impoundment: 200 Mil. gals; 600 acre ft.

No. and type of dwellings located adjacent to pond or reservoir i.e. summer homes etc. 87 COTTAGES, 1 HOUSE, 1 CAMP, 1 DAY CAMP

Dimensions of Dam: Length 25' Max. Height 9'
Slopes: Upstream Face 4:1
Downstream Face 2
Width across top 15'

Classifications of Dam by Materials:
Earth ✓. Conc. Masonary ____. Stone Masonary ____
Timber ____. Rockfill ____. Other ____

A. Description of present land usage downstream of dam: 90 % rural; 10 % urban

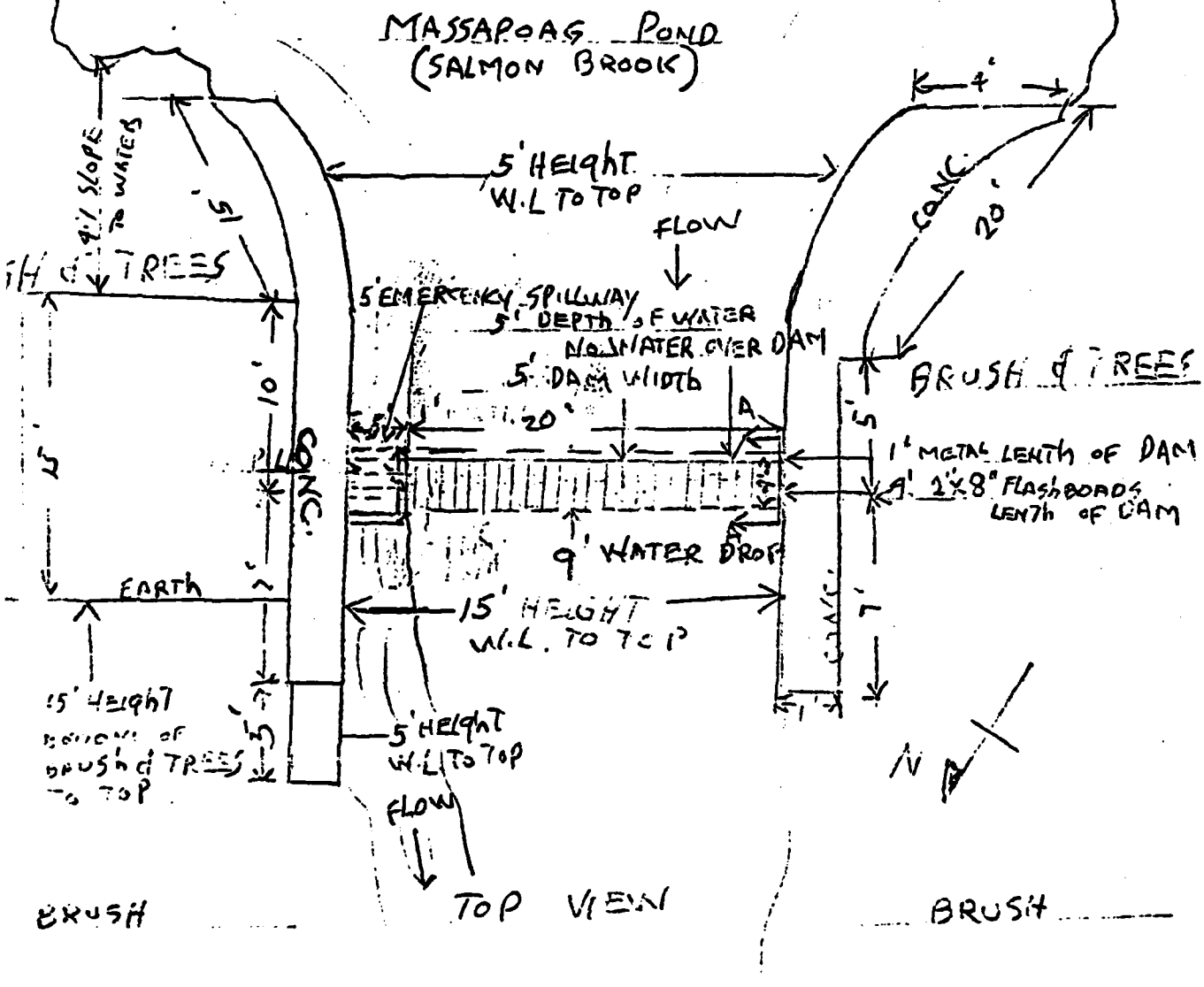
B. Is there a storage area or flood plain downstream of dam: which could accommodate the impoundment in the event of a complete dam failure no ____. yes ✓.

DAM NO. 4-9-81-2

Risk to life and property in event of complete failure.

No. of people NONE.
No. of homes 11.
No. of businesses NONE.
No. of industries 11. Type
No. of utilities 11. Type
Railroads NONE.
Other dams 11.
Other.

Attach sketch of dam to this form showing section and plan 8½"X11" Sheet.



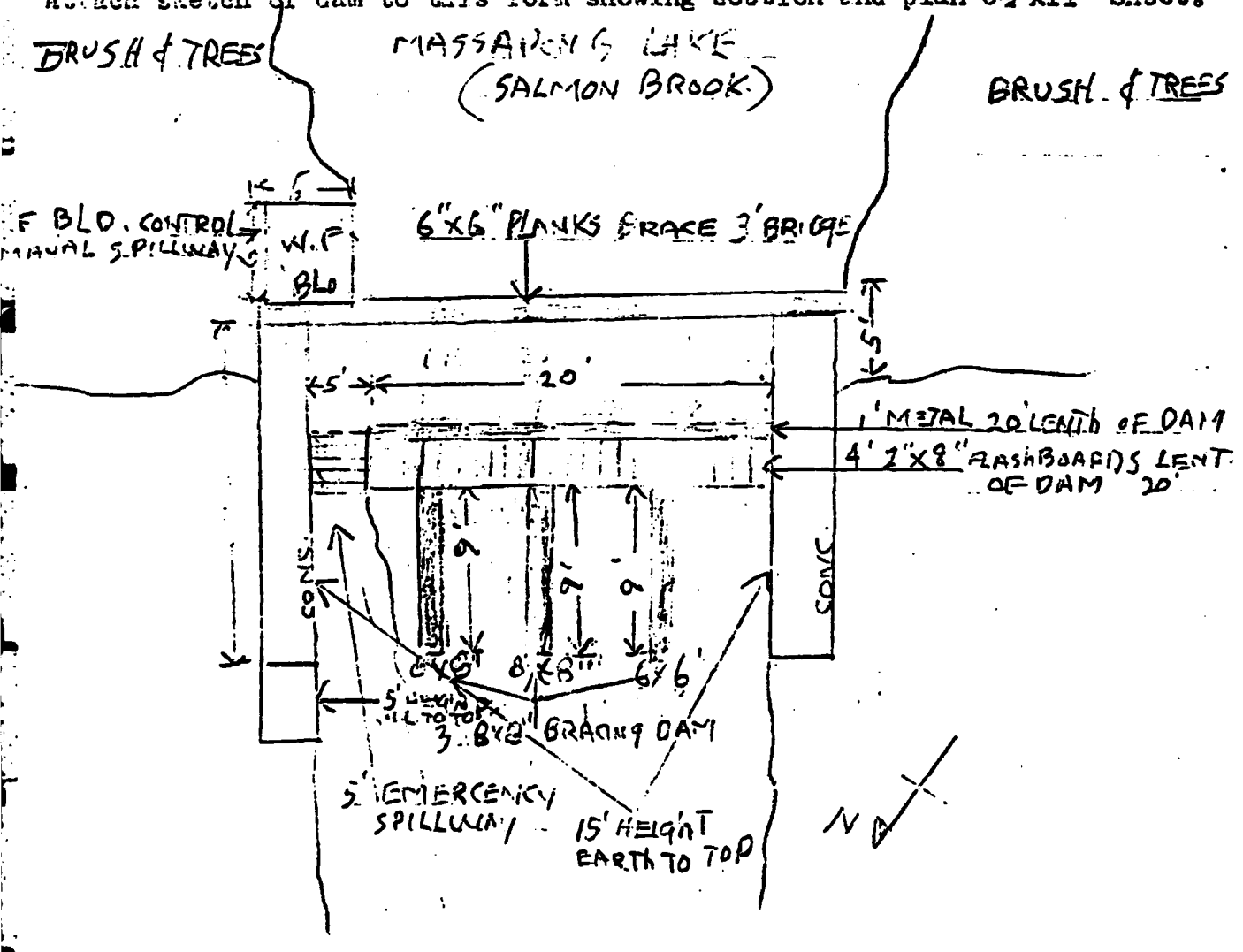
APPENDIX B-11

DAM NO. 4-9-81-2

Risk to life and property in event of complete failure.

No. of people NONE.
No. of homes " .
No. of businesses NONE.
No. of industries " . Type
No. of utilities " . Type
Railroads NONE.
Other dams " .
Other .

Attach sketch of dam to this form showing section end plan 8½"X11" Sheet.



SKETCH NOT TO SCALE

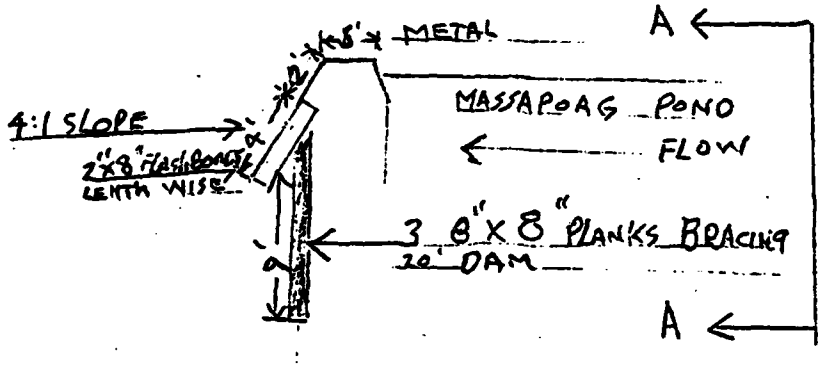
DAM NO. 4-9-81-2

Risk to life and property in event of complete failure.

No. of people NONE.
No. of homes " .
No. of businesses NONE.
No. of industries " .
No. of utilities " .
Railroads NONE.
Other dams " .
Other .

Type
Type

Attach sketch of dam to this form showing section and plan 8½"X11" Sheet.



X SECTION

SKETCH NOT TO SCALE

INSPECTION REPORT - DAMS AND RESERVOIRS

1) Location: ~~City~~/Town DUNSTABLE Dam No. 4-7-81-2

Name of Dam MASSAPOAG POND DAM Inspected by ADAM Z. PIZANI, FRANCIS H. PARE

Date of Inspection 11-17-73

2) Owners: per: Assessors _____ Prev. Inspection _____

Reg. of Deeds _____ Pers. Contact _____

	Name	St. & No.	City/Town	State	Tel. No.
1	DUNSTABLE ROD & GUN CLUB	DUNSTABLE	MASS	01827	649-7273
2					
3					

4) Caretaker: (if any) e.g. superintendent, plant manager, appointed by absentee owner, appointed by multi owners.

Name	St. & No.	City/Town	State	Tel. No
HOWARD SMALL	HALL ROAD	DUNSTABLE	MASS. 01827	649-7273

5) No. of Pictures taken 3

6) Degree of Hazard: (if dam should fail completely)*

1. Minor ✓ 2. Moderate _____

3. Severe _____ 4. Disastrous _____

*This rating may change as land use changes (future development)

7) Outlet Control: Automatic _____ Manual ✓

Operative ✓ Yes: _____ No.

Comments: FLASHBOARDS CONTROL EMERGENCY SPILLWAY

8) Upstream Face of Dam: Condition:

1. Good ✓ 2. Minor Repairs _____

3. Major Repairs _____ 4. Urgent Repairs _____

Comments: DAM REPAIRED 10-17-73

Comments:

rgency Spillway: Condition: 1.Good ✓ 2. Minor Repairs ____

3. Major Repairs ____ 4. Urgent Repairs ____

Comments:

ter level @ time of inspection 2 ft. above ____ below ✓

top of dam ____ Principal spillway ✓

other ____

mmary of Deficiencies Noted:

Growth (Trees and Brush) on Embankment

Animal Burrows and Washouts

Damage to slopes or top of dam

Cracked or Damaged Masonry

Evidence of Seepage

Evidence of Piping

Erosion

Leaks

Trash and/or debris impeding flow

Clogged or blocked spillway

Other

REPAIRS ON DAM COMPLETED 10-17-73.
WATER BUILDING UP, AS OF INSPECTION
TIME, 11-17-73.., FLASHBOARDS 2"X8" 5'X5',
3 WOOD BEAMS BRACING SPILLWAY, 8"X8" 9' HEIGHT
F 2"X8" FLASHBOARDS 4', 4:1 SLOPE DIFFERENT
OCATION, 20' LENTH.

Overall Condition:

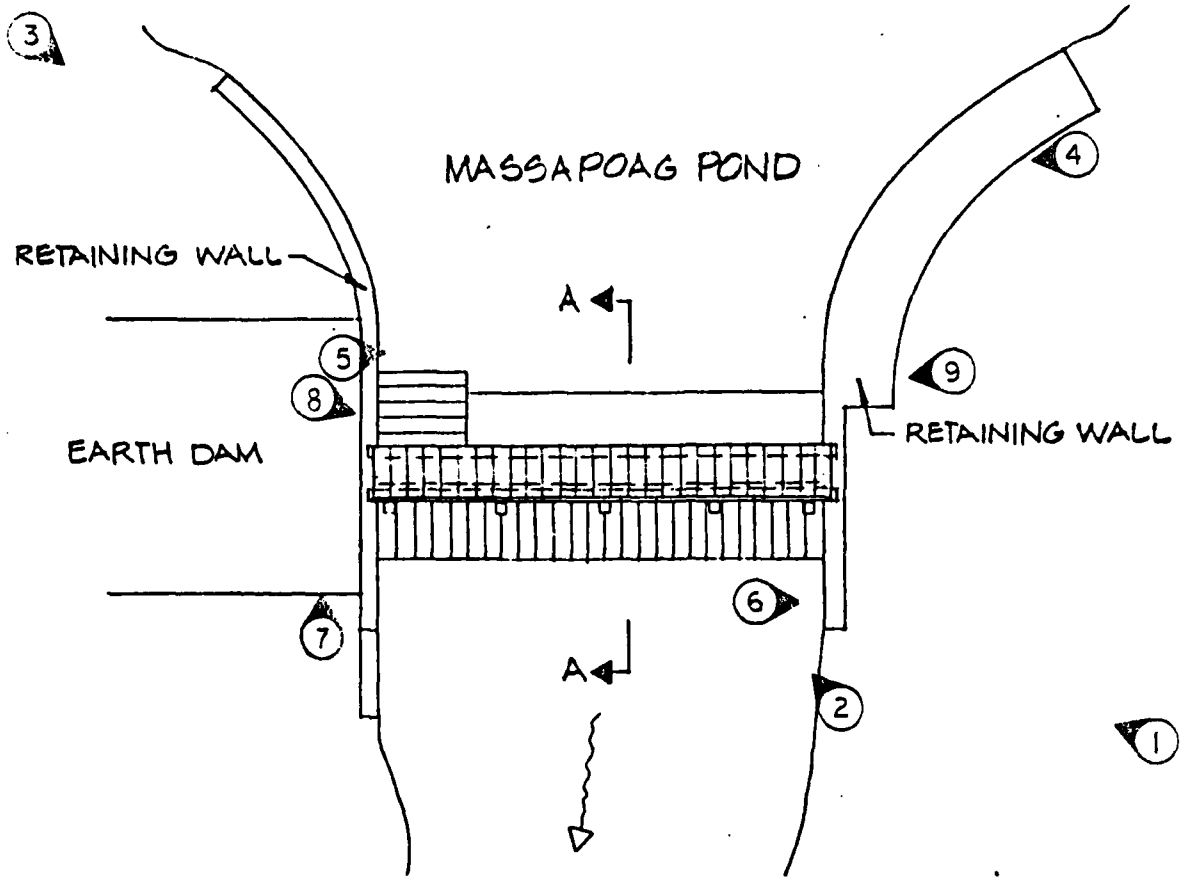
1. Safe ✓
2. Minor repairs needed _____
3. Conditionally safe - major repairs needed _____
4. Unsafe _____
5. Reservoir impoundment no longer exists (explain)

Recommend removal from inspection list NO

APPENDIX C

SELECTED PHOTOGRAPHS OF PROJECT

		Page No.
LOCATION PLAN		
	Location of Photographs	C-1
PHOTOGRAPHS		
No.	**Title**	**Page No.**
1.	Overview of Dam	Follows Table of Contents
2.	Downstream Face of Dam	C-2
3.	View of Dam From Upstream Right Embankment	C-2
4.	Approach Channel, Right Training Wall	C-3
5.	Approach Channel, Left Training Wall	C-3
6.	Deteriorated Timbers at Left Side of Spillway, Downstream of Crest	C-4
7.	Missing Stone in Downstream Right Sidewall of Spillway	C-4
8.	Reservoir Drain Gate Operator and Footbridge From Right Abutment	C-5
9.	Reservoir Drain Gate Operator and Footbridge From Left Abutment	C-5



PLAN

CAMP DRESSER & McKEE INC. BOSTON, MASSACHUSETTS	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON FED. DAMS

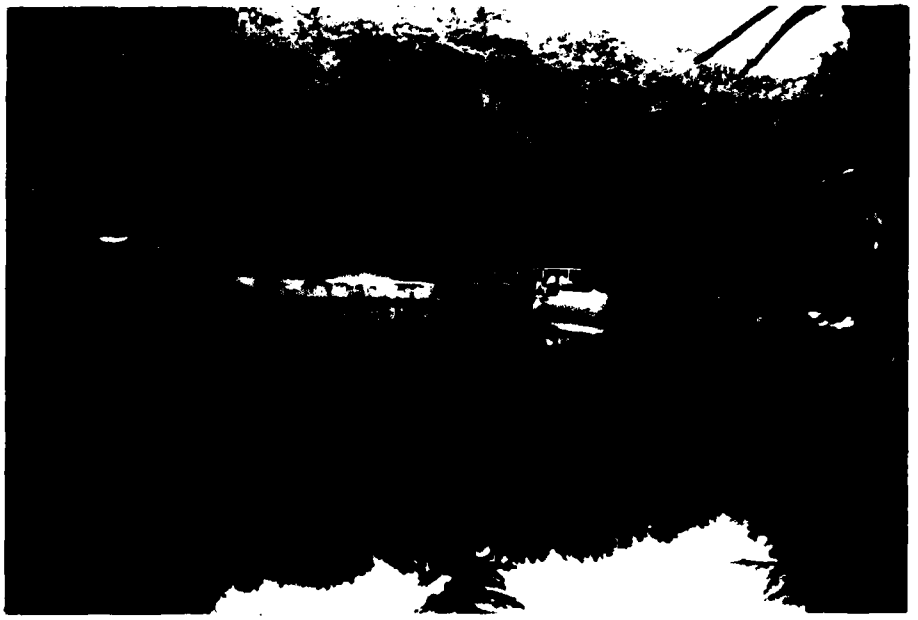
MASSAPOAG DAM
PLANS & SECTION

MASSAPOAG POND MASSACHUSETTS

			SCALE: NONE
			DATE: AUG. 1978

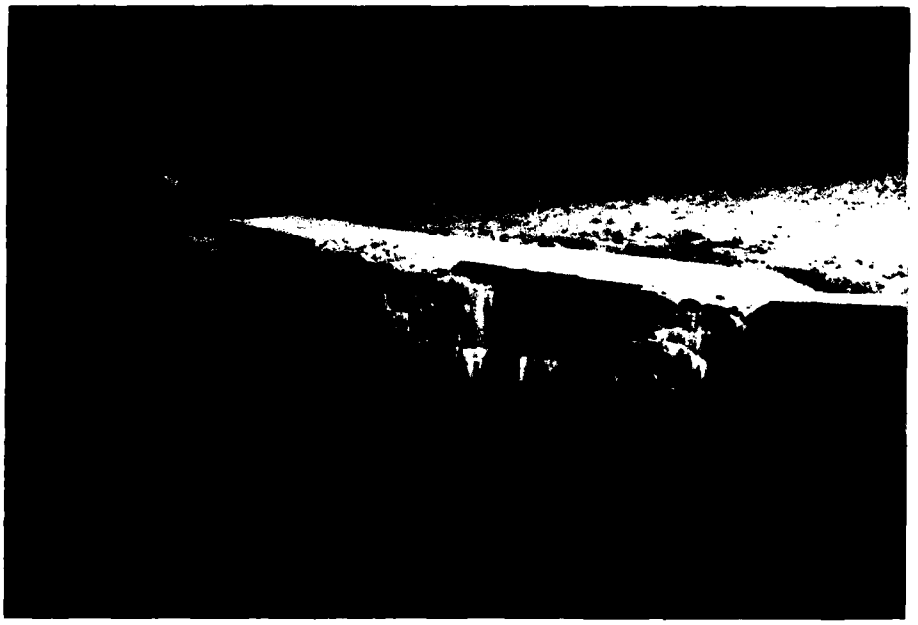
APPENDIX C-1

2. VIEW OF DOWNSTREAM FACE OF DAM.



3. VIEW OF DAM FROM UPSTREAM RIGHT EMBANKMENT.

4. APPROACH CHANNEL RIGHT TRAINING WALL.



5. APPROACH CHANNEL LEFT TRAINING WALL.

6. DETERIORATED TIMBERS AT LEFT SIDE OF SPILLWAY DOWNSTREAM OF CREST.

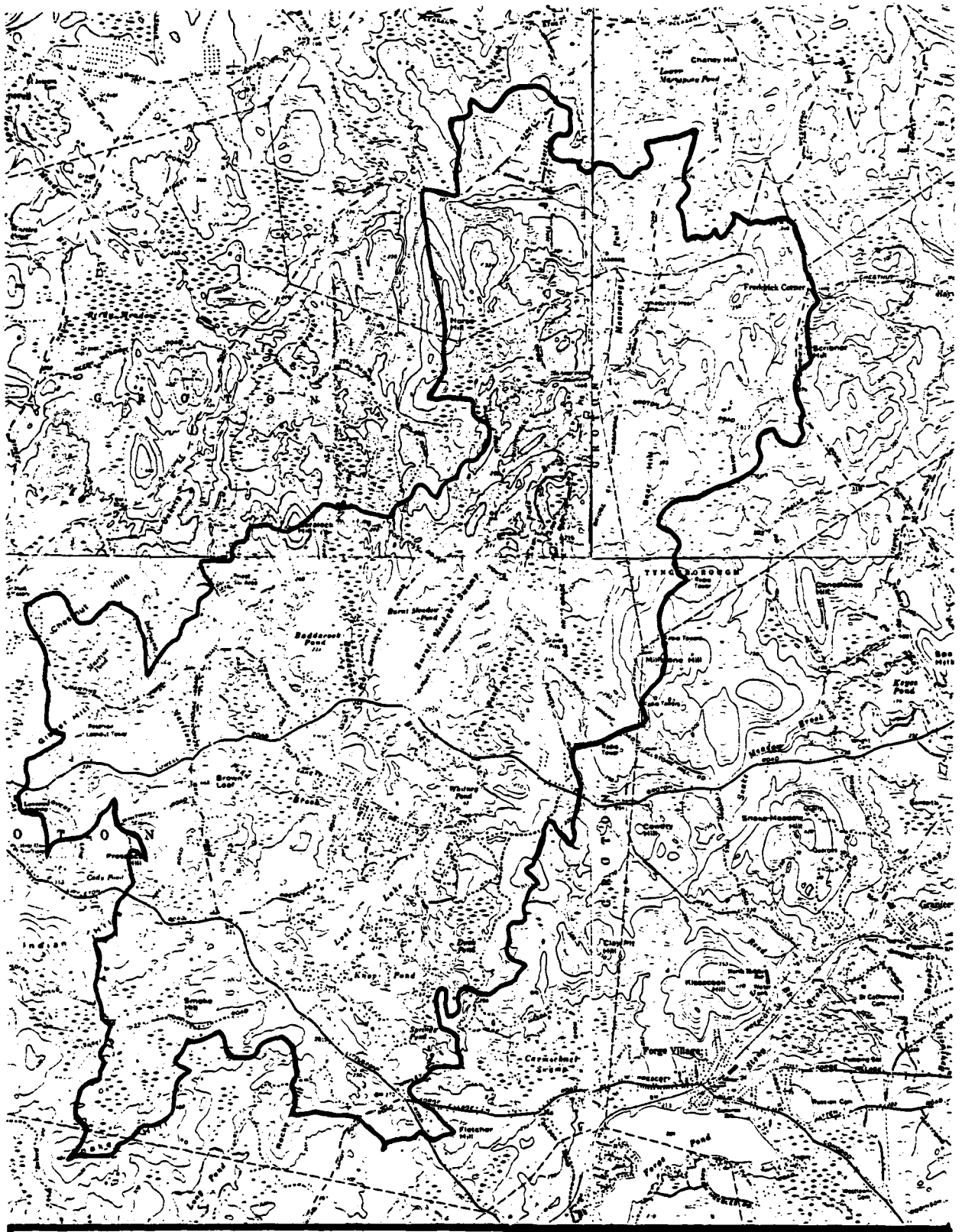
7. MISSING STONE IN DOWNSTREAM RIGHT SIDE WALL OF SPILLWAY.

8. RESERVOIR DRAIN GATE OPERATOR AND FOOTBRIDGE FROM RIGHT ABUTMENT.

9. RESERVOIR DRAIN GATE OPERATOR AND FOOTBRIDGE FROM LEFT ABUTMENT.

APPENDIX D
OUTLINE OF DRAINAGE AREA AND HYDRAULIC COMPUTATIONS

	Page No.
OUTLINE OF DRAINAGE AREA	
Drainage Area Map	1
COMPUTATIONS	
Elevations; Surface Areas; and Storage Capacities	2
Size Classification; Hazard Potential	3
Test Flood; Drainage Area; and 100-Year-Flood Determination	4
Dam & Spillway Rating Curve	5
Surcharge Storage Routing	6
Dam Failure Analysis - Hunsepong Pond	7-12
Routing Analysis - Lower Hunsepong Pond	13-15



CAMP DRESSER & McKEE Inc. **Consulting Engineers** **Boston, Mass.**	N	MASSAPOAG POND DAM DRAINAGE AREA MAP SCALE: 1" = 4000'

APPENDIX D-1

CAMP DRESSER & McKEE
Environmental Engineers
Boston Mass

CLIENT ACE
PROJECT LANI T.S.P.
DETAIL MASSAPOAG POND

JOB NO 3PC-5-C3
DATE CHECKED Oct 2 1978
CHECKED BY [illegible]

PAGE 1 of 14
DATE 9-13-16
COMPUTED BY JED

ELEVATIONS

There is no set crest elevation for Massapoag Pond Dam. USGS Quad: NASHUA SOUTH, MA.-N.H, 1965 shows the pond elev. & Elev. 161.0 - assume to equal crest elev.

CREST ELEV. = 161.0
TOE OF SPILLWAY = 161 - 10.0 = 151.0
TOP OF LEFT ABUTMENT WALL = 161 + 3.67 = 164.67
TOP OF LEFT EMBANKMENT = 161 + 2.67 = 163.67
TOP OF RIGHT ABUTMENT WALL = 161 + 4.25 = 165.25
TOP OF RIGHT EMBANKMENT: VARIES FROM 165.25-0.57 = 164.68 @ ABUTMENT TO 165.25-1.6 = 163.65 @ ABOUT THE CENTER
BOTTOM OF WOODEN WALKWAY = 161 + 3.56 = 164.56
TOP OF WOODEN WALKWAY = 161 + 3.56 + 0.5 = 165.06

SURFACE AREAS

POND @ Elev. 161.0 = 109.7 acres
Elev. 170.0 = 165.3 "
Elev. 180.0 = 214.0 "

Elev. 163.65 = (165.3-109.7)/9 x 2.65 + 109.7 = 126.0
Elev. 164.74 = (165.3-109.7)/9 x 3.74 + 109.7 = 132.6

STORAGE CAPACITIES

At Crest Elev. 161.0 = 109.7 x 10 x 1/3 = 366 ac-ft.
@ Elev. 170.0 = $366 + \left(\frac{109.7+165.3}{2}\right) \times 9 = 1,604$ ac-ft.
@ Elev. 180.0 = $1604 + \left(\frac{165.3+214.0}{2}\right) \times 10 = 3500$ ac-ft.

@ Top of Dam (Elev. 163.65) = $\frac{1604-366}{9} \times 2.65 + 366 = 730$ ac-ft.

@ Top of Left Abutment (Elev. 164.67)
= (1604 - 366)/9 x 3.67 + 366 = 870 ac-ft.

at test flood (Elev. 164.74)
= (1604 - 366)/9 x 3.74 + 366 = [illegible] ac-ft.

APPENDIX D-2

SIZE CLASSIFICATION

HYDRAULIC HEIGHT: Toe of Spillway to top of Spillway Wingwalls = 15'-6"

STORAGE CAPACITIES: @ Top of Dam (El. 163.65) = 730 ac-ft
@ Top of Abutment (El. 164.67) = 870 ac-ft.

∴ SIZE CLASSIFICATION IS SMALL

HAZARD POTENTIAL

DEQE has rated the degree of Hazard (if the dam should fail completely) as being minor.

A review of the downstream conditions based on the USGS Quads is summarized in the following table.

REACH NO.	DOWNSTREAM CONTROL	LENGTH (ft)	DEGREE OF DEVELOPMENT
1	Pleasant St.	5,200	None
2	Main St.	2,700	None
3	Ridge Rd.	11,000	None
4	Searles Rd.	4,000	None
5	East Dunstable Rd.	3,800	Slight Residential
6	Northeastern Blvd.	4,000	Moderate Residential
7	—	5,000	City of Nashua
		35,700' = 6.6 miles	

The 1st Reach between the dam site and Pleasant St. is Lower Massapoag Pond. Much flood plain storage is available within Reaches 1-4.

On the basis of the above, the hazard is considered a low-significant : damages to roads, bridges, and utilities.

TEST FLOOD

Hazard SIGNIFICANT & Size SMALL → TEST FLOOD = 100-YR to 1/2 PMF

Since the hazard is a low-significant, use 100-YR.

DRAINAGE AREA

From USGS Quads : 13.56 mi²

The sideslopes into the watershed are moderately steep. However, the series of Lakes, Ponds, Swamps, and Brooks which drain the basin are quite flat. Surface water and swamps have been estimated to be ~ 53% of the drainage area.

100 YEAR FLOODS

A. Johnson & Tasker Method :

$$P_{100} = 0.260\, A^{0.94}\, S^{0.187}\, p^{4.08}$$

where A = Drainage Area, sq. mi.
S = Slope of Stream, ft./mi.,
p = Mean Annual Precipitation, ft.

Main Channel Slope: $L_{TOTAL} = 46{,}600'$; $L_{85\%-10\%} = 30450$ ft. = 5.77 mi.

Elev. @ 85% L = 305
Elev. @ 10% L = 457 ft. + 5.77 mi = 25 ft/mi.

A = 13.56 mi²,
p = 42" = 3.5'

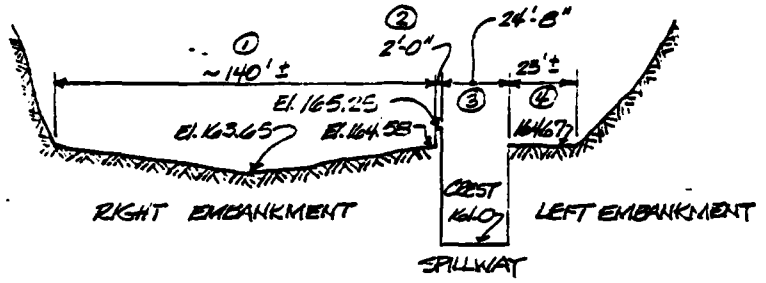
$$P_{100} = 0.26\,(13.56)^{0.94}\,(25)^{0.187}\,(3.5)^{4.08} = \underline{913\ cfs}$$

B. USGS Water Resources Invest. 77-99 METHOD :

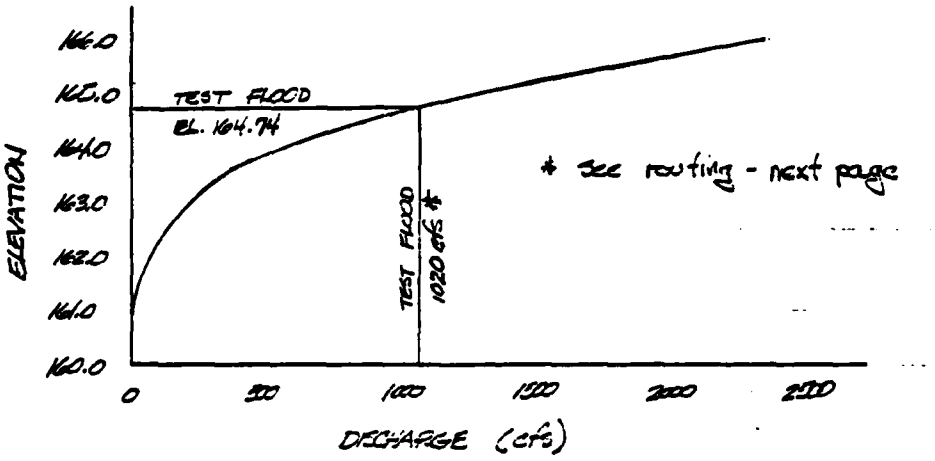
for Eastern Mass. $Q_{100} = 53.8\, A^{0.807}\, S_1^{0.272}$

$= 53.8\,(13.56)^{0.807}\,(25)^{0.272} = \underline{1050\ cfs}$

METHOD A & B compare well, use 1060 cfs for TEST FLOOD as it is more conservative



W.S. ELEV.	SECT. ① C = 2.5	SECT. ② C = 3.0	SECT. ③ C = 3.5	SECT. ④ C = 2.5	TOTAL FLOW
161.00	-	-	0	-	0
163.65	0	-	372	-	372
164.67	350	-	607	0	957
165.25	708	0	757	28	1,493
166.00	1261	4	965	96	2,326



STAGE - DISCHARGE RELATIONSHIPS

CAMP DRESSER & McKEE
Environmental Engineers
Boston, Mass.

CLIENT COE.
PROJECT WMI IHSP
DETAIL MASSAPOAG POND

JOB NO. 350-5-C2
DATE CHECKED Oct 29 1976
CHECKED BY CFuller

PAGE 5 of 14
DATE 1-25-78
COMPUTED BY JEO

Revised
11-30-76
JEO

SURCHARGE - STORAGE ROUTING

$Qp_1 = 1,060$ cfs

Surcharge $Ht_1 = 164.61 + (1060 - 957)/(1493 - 957) \times (165.25 - 164.67)$
$= 164.61 + (0.1922)(0.58) = 164.67 + 0.11 = 164.78$

STOR, @ El. 164.78 $= (1604 - 366)/9 \times (164.78 - 161.0)$
$= 1238/9 \times 3.78$
$= 137.56 \times 3.78 = 520$ ac.-ft.

$STOR_1 = 520/(53.3 \times 13.36) = 0.72$ inches

$Qp_2 = 1060 \times (1 - 0.72/6) = 933$ cfs

Surcharge $Ht_2 = 163.65 + (933 - 372)/(997 - 372) \times (1.02)$
$= 163.65 + (0.96)(1.02) = 163.65 + 0.98 = 164.63$

$STOR_2$ @ El. 164.63 $= (1604 - 366)/9 \times (164.63 - 161.0)$
$= 1238/9 \times 3.63$
$= 500$ ac.-ft.

AVG. STOR $= (520 + 500)/2 = 510$ ac.-ft.

Surcharge Ht.3 @ AVG. STOR (510 ac.-ft.)
$= (510)/(1604 - 366) \times 9 + 161.0$
$= 510/1238 \times 9 + 161.0$
$= 0.412 \times 9 + 161.0 = 3.74 + 161.0 = 164.74$

Qp_3 @ El. 164.74 $= (164.74 - 164.67)/(165.25 - 164.67)$
$\times (1493 - 957) + 957$
$= 0.07/0.58 \times 536 + 957$
$= 64.7 + 957 = 1022$ cfs

Say 1020 cfs

Dam Failure Analysis

$$Q_{pi} = \frac{8}{27} W_b \sqrt{g}\, Y_o^{\frac{3}{2}}$$

Assume that 40% of the section of dam fails. Assume that breach occurs at an elev. of Elev. 154 Lower Mosspond Pond, which is 154.0 ft below pond bottom @ spillway.

Then $Y_o = 163.65 - 154 = 9.65$ ft.

$$Q_{pi} = \frac{8}{27}(140)(0.4)\sqrt{32.2}\,(9.65)^{\frac{3}{2}} = 2822 \text{ cfs}$$

say 2800 cfs.

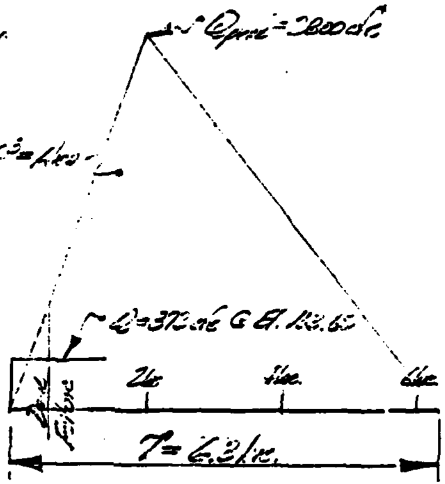
Now assume that total contents of Mosspond Pond (730 ac-ft) is spilled downstream with Δ hydrograph & peak flow occurring @ $\frac{T}{3}$

Vol $^{ac\text{-}ft}$ = 31,798,300 ft³ = Area

$$\frac{T}{2}(2800 \text{ cfs}) = 31,798,300 \text{ ft}^3$$

T = 6.31 hr = 378.5 min.

say T = 6 hr 20 min.



Consider volume of flow passed downstream with time:

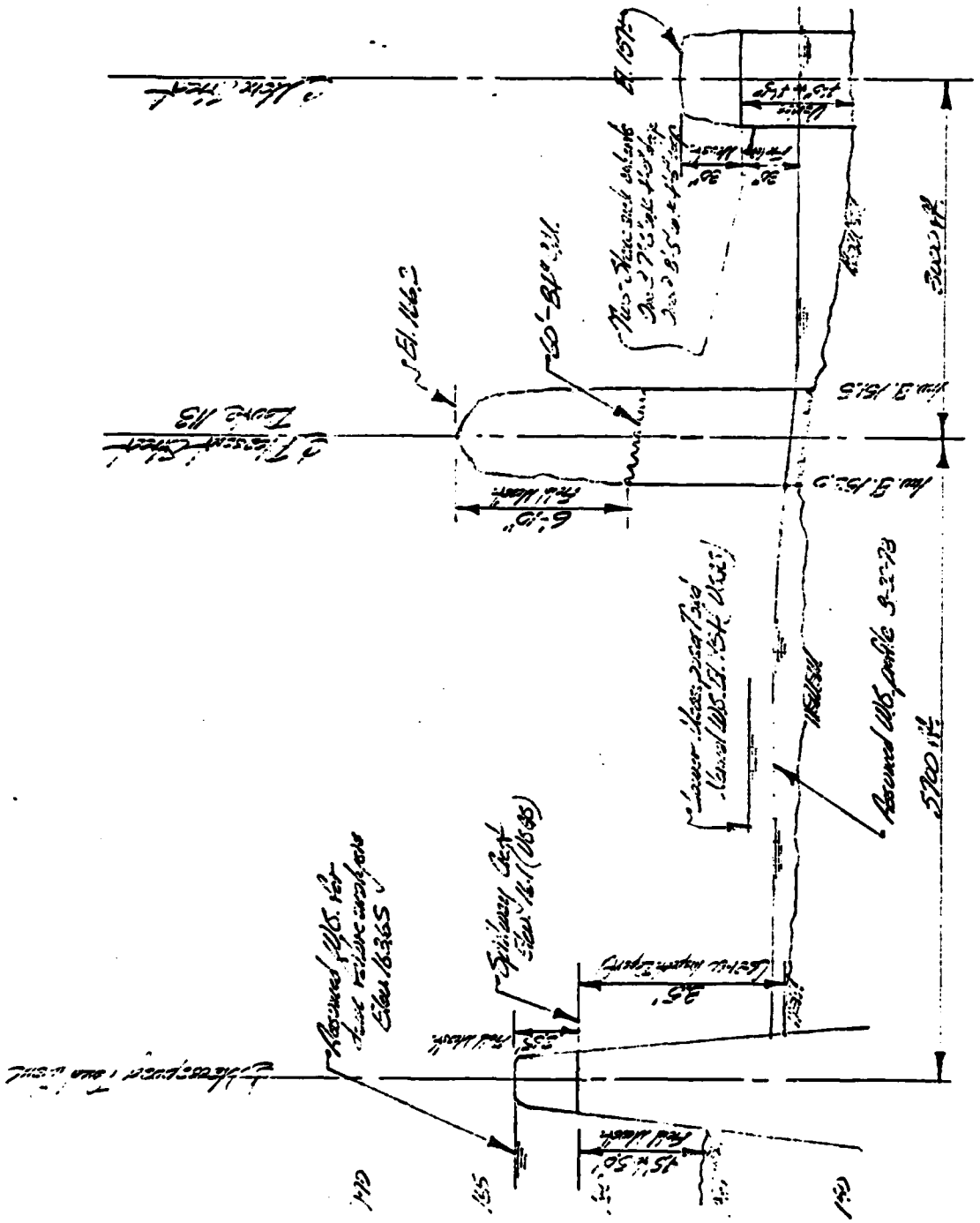
Time	Inflow	Cumulative Inflow	Water Surf. Elev. Mosspond Pond
0	0	0	163.65
1 hr	1400 cfs	2,520,000 ft³	163.28
2 hr	2800	10,080,000	161.99
3	2150	18,890,000	160.40
4	1500	25,560,000	159.[illegible]
5	840	29,772,000	
6	180	31,608,000	
6.32	0	31,798,500	

CAMP DRESSER & McKEE
Environmental Engineers
Boston, Mass.

CLIENT
PROJECT
DETAIL

JOB NO.
DATE CHECKED 21 Oct 1978
CHECKED BY

PAGE
DATE
COMPUTED BY



APPENDIX D-8

Determine capacity of 60'-84" C.M. beneath Pleasant Street

assume n = 0.024 and S = 0.010, then Q_{full} = 330 cfs V_{full} = 8.59 fps

$\frac{V^2}{2g}$ = 1.230'

pressure operation

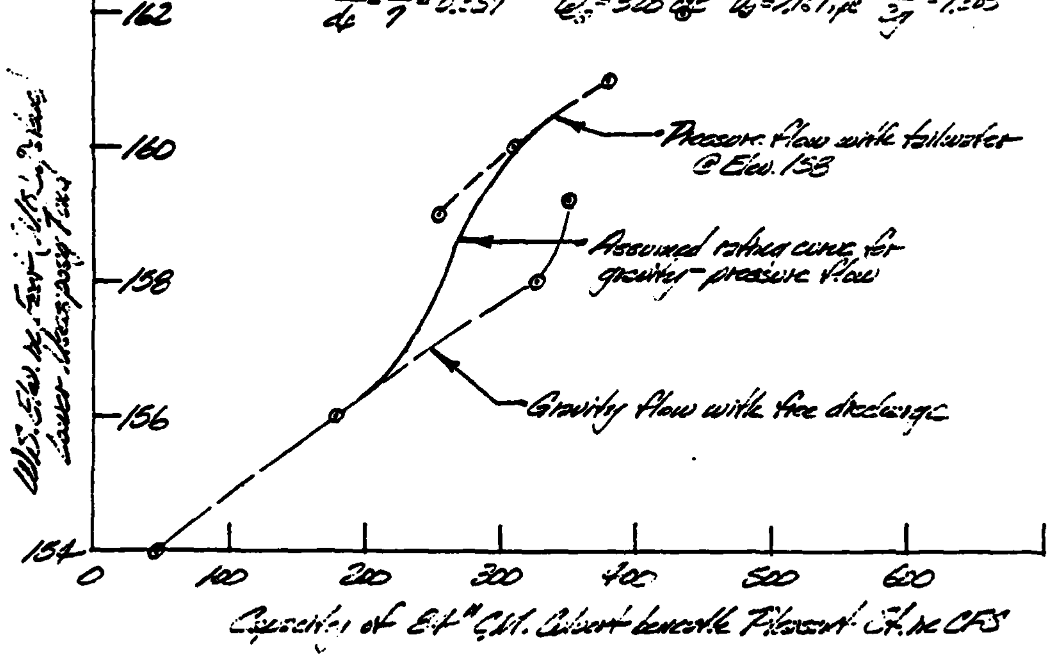
161-158 = 3.0' Q = 380 cfs
160-158 = 2.0' Q = 310 cfs
159-158 = 1.0' Q = 255 cfs
162-158 = 4.0' Q = 425 cfs

From "Handbook of Steel Drainage and Highway Construction Products" by AISC Nomograph on Pg. 114

if u.s. WS @ El. 154, $\frac{d}{d_c} = \frac{2}{7}$ = 0.2857 Q_g = 48.3 cfs V_g = 5.05 fps $\frac{V^2}{2g}$ = 0.402'

if u.s. WS @ El. 156, $\frac{d}{d_c} = \frac{4}{7}$ = 0.571 Q_g = 179.2 cfs V_g = 7.615 fps $\frac{V^2}{2g}$ = 0.900'

if u.s. WS @ El. 158, $\frac{d}{d_c} = \frac{6}{7}$ = 0.857 Q_g = 328 cfs V_g = 7.167 fps $\frac{V^2}{2g}$ = 1.305'



APPENDIX D-9

CAMP DRESSER & McKEE
Environmental Engineers
Boston, Mass.

CLIENT Corps of Engineers JOB NO. 366-? PAGE 9 of 11
PROJECT [illegible] DATE CHECKED 24 Oct 1978 DATE [illegible]
DETAIL [illegible] CHECKED BY [illegible] COMPUTED BY [illegible]

Calculate capacity of [illegible] culverts

7.5' 8.5' $n = 0.030$

4.0' 4.5

$A = (4.0)(7.5) + (8.5)(4.5) = 68.25$ sf

$R = \frac{68.25}{49.?} = 1.39$

$Q = (68.25\ ft^2)\left(\frac{1.49}{0.030}\right)(1.393)^{\frac{2}{3}}(s)^{\frac{1}{2}} = 4216.382\ s^{\frac{1}{2}}$

if $s = 2.0'$ in $50' = 0.040$,

$Q = 843.3$ cfs $V_{ave} = 12.36$ fps $\frac{V^2}{2g} = 2.37'$ $H = 0.2\frac{V^2}{2g} + 0.7\frac{V^2}{2g} + s$

$= 0.9(2.37) + 2.0 = 4.13'$

if $s = 1.5'$ in $50' = 0.030$,

$Q = 730$ cfs $V_{ave} = 10.70$ fps $\frac{V^2}{2g} = 1.773'$ $H = 1.60 + 1.5 = 3.10'$

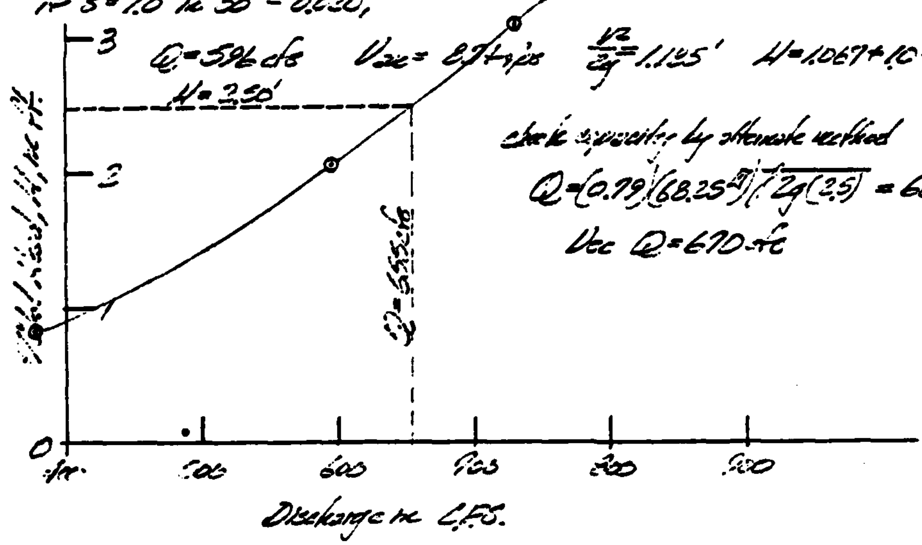
if $s = 1.0'$ in $50' = 0.030$,

$Q = 596$ cfs $V_{ave} = 8.74$ fps $\frac{V^2}{2g} = 1.185'$ $H = 1.067 + 1.0 = 2.07'$

check capacity by alternate method

$Q = (0.79)(68.25\ ft^2)\sqrt{2g(2.5)} = 684$ cfs

Use $Q = 670$ cfs



APPENDIX D-10

CAMP DRESSER & McKEE
Environmental Engineers
Boston, Mass.

CLIENT [illegible]
PROJECT [illegible]
DETAIL [illegible]
JOB NO. [illegible]
DATE CHECKED 27 Oct 1978
CHECKED BY [illegible]
PAGE [illegible]
DATE [illegible]
COMPUTED BY [illegible]

Consider available storage in Lower [illegible] Pond

Lower [illegible] Pond (Elev. 154)

8615 .18
8597 .42
8545 .32
8513

3) 1.02

0.34 [illegible] (600/584)(2000 1/11)² = 1,385,400 [illegible] − (400)(250) island = 1,285,400 [illegible]

Elev. 160

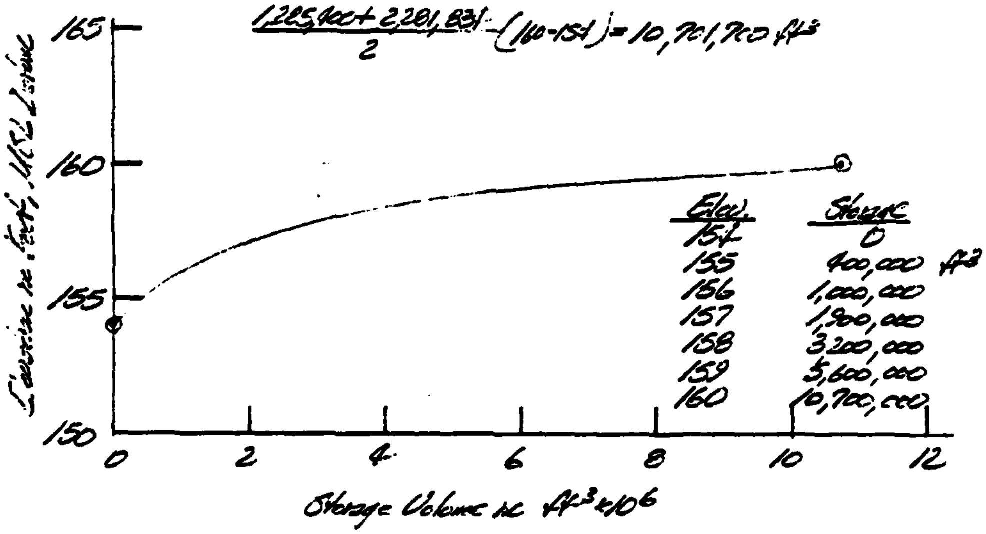
8727 .57
8670 .55
8615

2) 1.12

0.56 [illegible] (600/584)(2000 1/11)² = 2,281,834 [illegible]

Total Available Storage between Elev 154 and Elev. 160

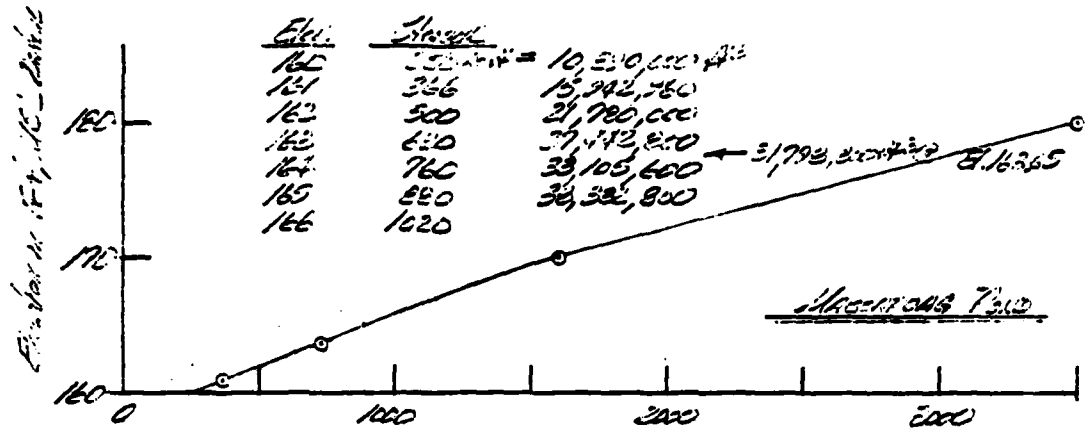
(1,285,400 + 2,281,834)/2 (160−154) = 10,701,700 ft³

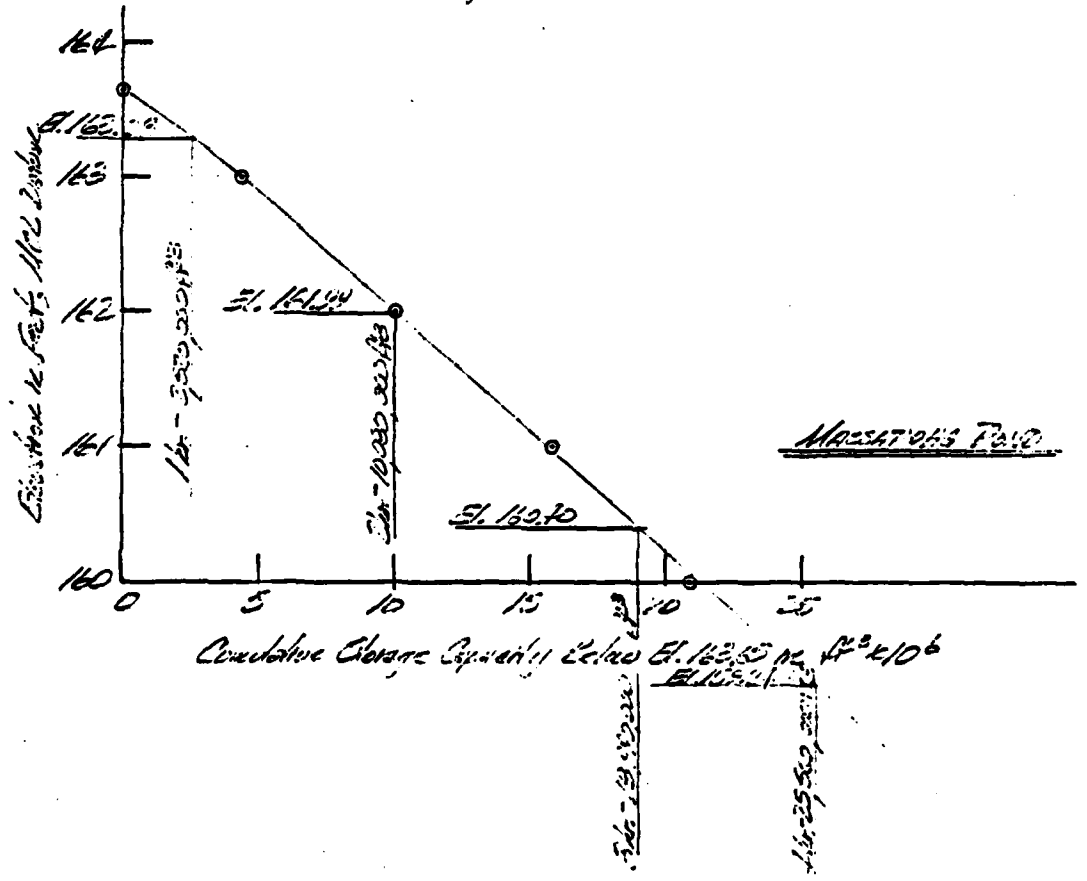


APPENDIX D-11

CAMP DRESSER & McKEE
Environmental Engineers
Boston, Mass.

CLIENT _____ JOB NO. _____ PAGE _____
PROJECT _____ DATE CHECKED 24 Oct 1978 DATE _____
DETAIL _____ CHECKED BY _____ COMPUTED BY _____





APPENDIX D-12

CAMP DRESSER & McKEE
Environmental Engineers
Boston, Mass.

CLIENT [illegible] JOB NO. [illegible] PAGE [illegible]
PROJECT [illegible] DATE CHECKED 24 Oct 1978 DATE [illegible]
DETAIL [illegible] CHECKED BY [illegible] COMPUTED BY [illegible]

[illegible]

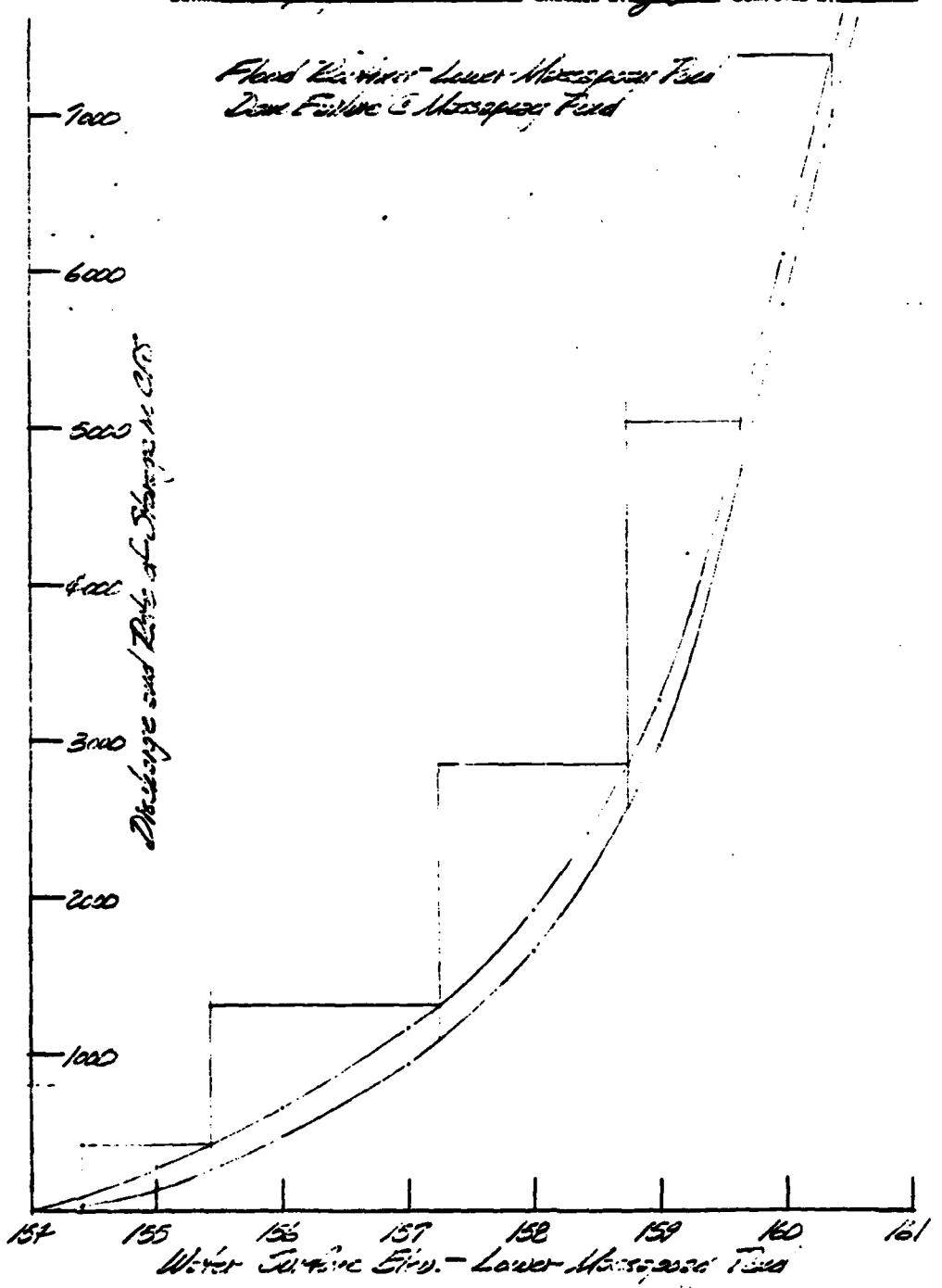
Water Surf. Elev.-Lower Mississquoi Pond (ft)	Water Surf. Area-Lower Mississquoi Pond (sq ft)	Calculated Outflow thru 54" C.M. culvert (cfs)	Storage, S in ft³	$\frac{S}{\Delta t}$ (cfs)	$\frac{S}{\Delta t} - \frac{O}{2}$ (cfs)	$\frac{S}{\Delta t} + \frac{O}{2}$ (cfs)
154	1,285,900 ft²	45 cfs	0			
155	—	110	400,000	222.2	167.2	277.2
156	—	180	1,000,000	555.6	465.6	[illegible]
157	—	230	1,900,000	1055.6	940.6	[illegible]
158	—	257	3,200,000	1777.8	1649	[illegible]
159	—	280	5,600,000	3111.1	2971	3251
160	2,281,834	315	10,700,000	5944.4	5787	6102
161	—	380				

Flood Routing - Lower Mississquoi Pond - Dam Failure @ Mississquoi

Time Number		Changed Inflow I, cfs	Average Inflow I, cfs	$\frac{S}{\Delta t} - \frac{O}{2}$ (cfs)	$\frac{S}{\Delta t} + \frac{O}{2}$ (cfs)	Outflow O (cfs)	Water Surf. Elev.-Lower Mississquoi Pond (ft)
0	0	0	0			73 cfs	154.40
1	30 min	700 cfs	350	70	420	150	155.1[illegible]
2	1 hr	1400	1050	210	1310	229	157.[illegible]
3	1 hr 30 min	2100	1750	1070	2810	275	158.[illegible]
4	2 hr	2800	2450	2590	5040	300	159.65
5	2 hr 30 min	2475	2640	4730	7370	346	160.40
6	3 hr	2150	2310	7000	9310	381	161.05
7	3 hr 30 min	1825	1990	8940	10,930	Routing	
8	4 hr	1500	1660			Discontinued due to	
9	4 hr 30 min	1170	1340			equilibrium condition	
10	5 hr	840	1000			between Mississquoi &	
11	5 hr 30 min	510	675			Lower Mississquoi Ponds	
12	6 hr	180	345				

CAMP DRESSER & MCKEE
ENVIRONMENTAL ENGINEERS
BOSTON, MASS.

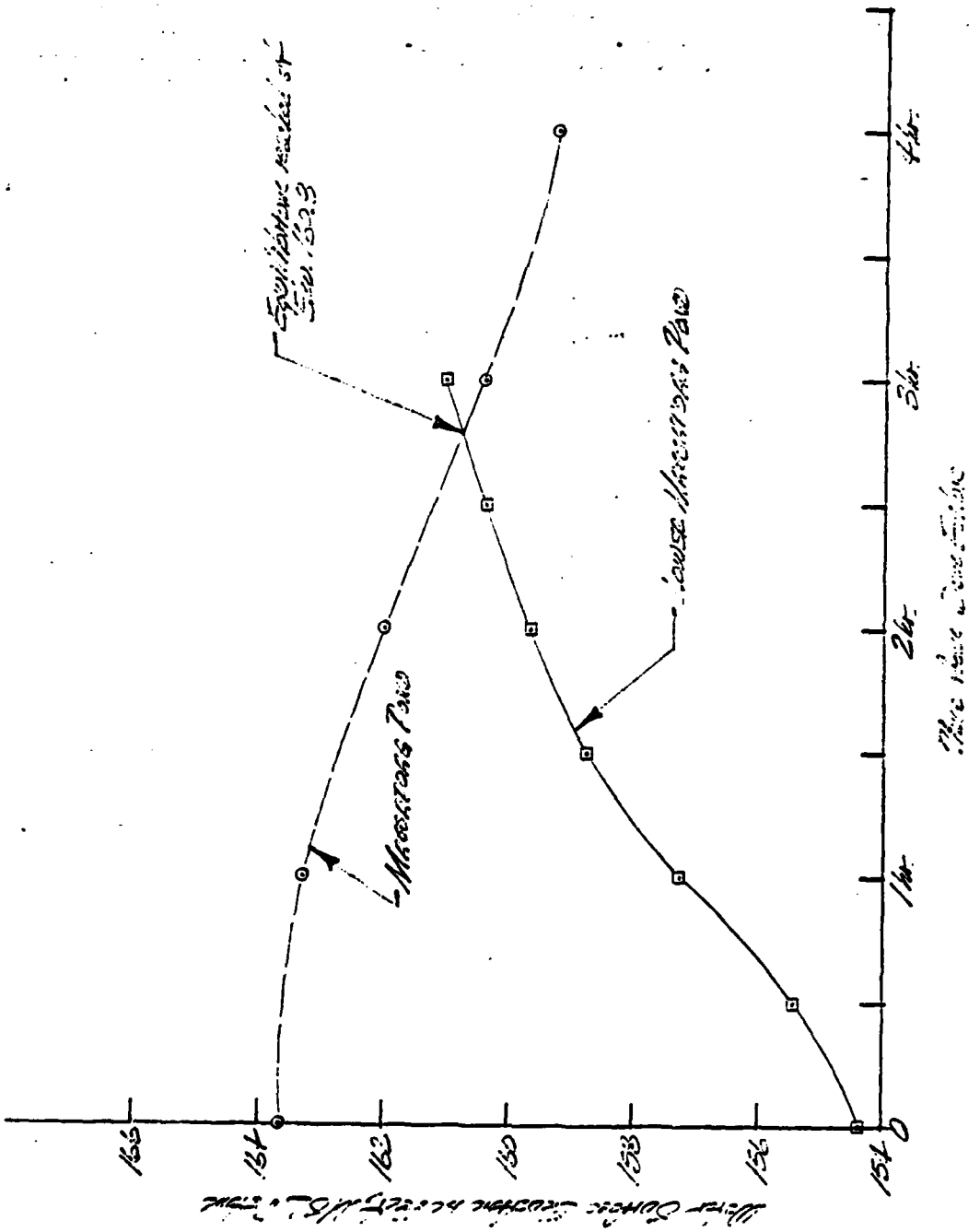
CLIENT Corps of Engineers JOB NO. 360-5-3 PAGE 13 of 14
PROJECT Refined Feasibility Study DATE CHECKED 2 Oct 79 DATE Oct 26, '79
DETAIL Mississippi River CHECKED BY JJA COMPUTED BY [illegible]



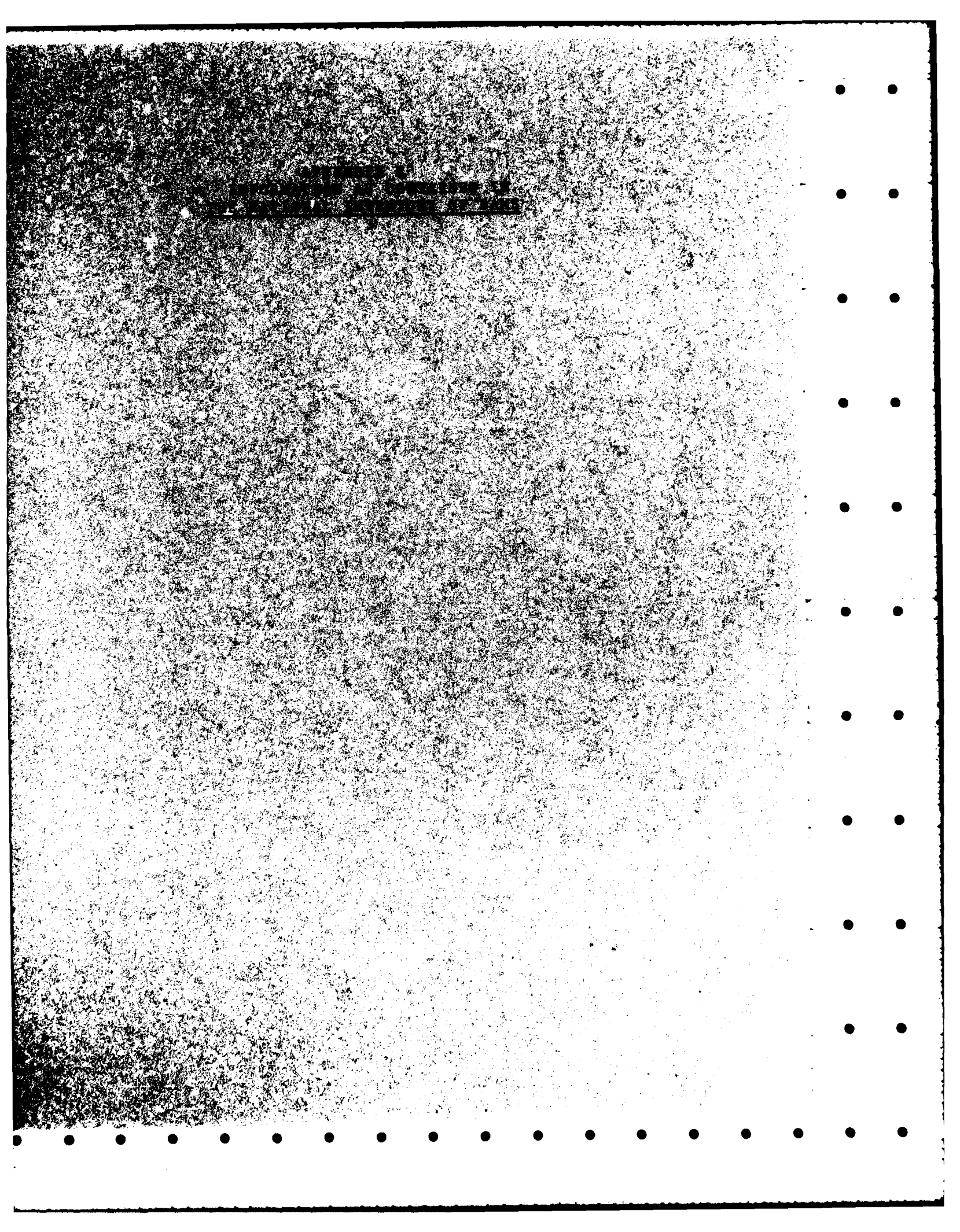
APPENDIX D-14

CAMP DRESSER & McKEE
Environmental Engineers
Boston, Mass.

CLIENT
PROJECT
DETAIL
JOB NO.
DATE CHECKED 24 Oct 1988
CHECKED BY
PAGE
DATE
COMPUTED BY



APPENDIX D-15



INVENTORY OF DAMS IN THE UNITED STATES

STATE	IDENTITY NUMBER	DIVISION	STATE	COUNTY	CONGR DIST.	STATE	COUNTY	CONGR DIST.	NAME	LATITUDE (NORTH)	LONGITUDE (WEST)	REPORT DATE DAY | MO | YR
MA	136	NED	MA	017	05				MASSAPOAG POND DAM	4239.5	7129.8	30AUG78

POPULAR NAME	NAME OF IMPOUNDMENT
	MASSAPOAG POND

REGION	BASIN	RIVER OR STREAM	NEAREST DOWNSTREAM CITY–TOWN–VILLAGE	DIST FROM DAM (MI.)	POPULATION
01	05	SALMON BROOK	NASHUA	0	61800

TYPE OF DAM	YEAR COMPLETED	PURPOSES	STRUCTURAL HEIGHT (FT.)	HYDRAULIC HEIGHT (FT.)	IMPOUNDING CAPACITIES MAXIMUM (ACRE–FT.)	IMPOUNDING CAPACITIES NORMAL (ACRE–FT.)	DIST	OWN	FED R	PRV/FED	SCS A	VER/DATE
RECTTRPG		R	13	14	880	366	NED	N	N	N	N	40EC78

REMARKS

D/S HAS	SPILLWAY CREST LENGTH	SPILLWAY TYPE	SPILLWAY WIDTH (FT.)	MAXIMUM DISCHARGE (FT.)	VOLUME OF DAM (CY)	POWER CAPACITY INSTALLED (MW)	POWER CAPACITY PROPOSED (MW)	NAVIGATION LOCKS NO.	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)
3	192	U	25	372												

OWNER	ENGINEERING BY	CONSTRUCTION BY
CAMBRIDGE YMCA		

REGULATORY AGENCY			
DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NONE	NONE	NONE	NONE

INSPECTION BY	INSPECTION DATE DAY | MO | YR	AUTHORITY FOR INSPECTION
CAMP DRESSER & MCKEE INC	22AUG78	PL 92-367

REMARKS

END

FILMED

10-84

DTIC